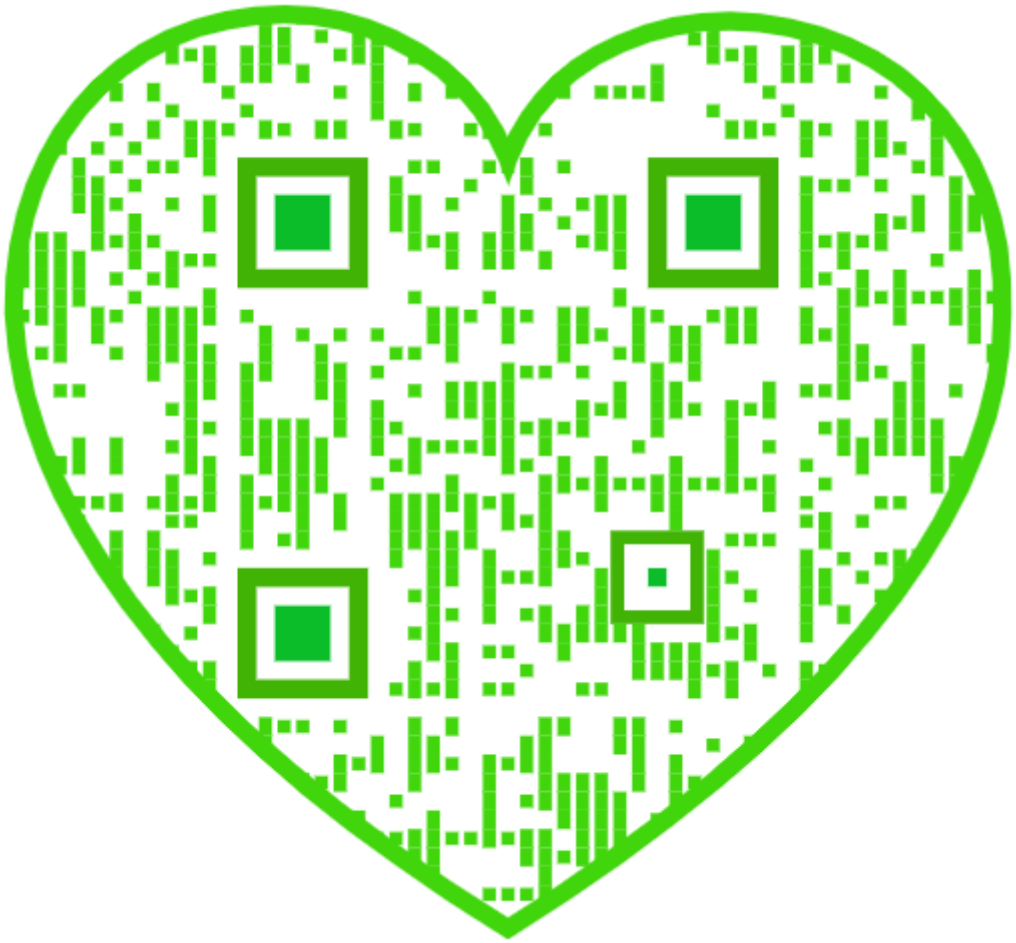


Stephens'
Book of the Farm

Wherefore come on, O young husbandman!
Learn the culture proper to each kind.

VIRGIL.

Stephens' Book of the Farm

Dealing exhaustively
with every Branch of Agriculture

FIFTH EDITION

REVISED AND LARGELY REWRITTEN BY

JAMES MACDONALD, F.R.S.E.

SECRETARY OF THE HIGHLAND AND AGRICULTURAL SOCIETY OF SCOTLAND

AUTHOR OF
'FOOD FROM THE FAR WEST,' 'POLLED CATTLE' AND 'HEREFORD CATTLE' (JOINTLY),
'SYSTEMS OF LAND TENURE,' ETC., ETC.

IN THREE VOLUMES

VOLUME II.—FARM CROPS

WILLIAM BLACKWOOD AND SONS
EDINBURGH AND LONDON

CONTENTS OF VOLUME II.

EXPERIMENTS IN MANURING CROPS.

Rothamsted Experiments. PAGE

Their origin 1
Main features of the work . 1
The soil 2
Scope of the manurial experiments . 2
Soil and drainage-water investigations 3
Scientific character of the trials . 3
Experiments on the continuous growth of wheat—
Without manure 3
With farmyard manure . . 4
Plant-food in dung . . . 4
Limits to high manuring . . 4
Nitrogen in dung . . . 5
Mechanical influence of dung . 5
With ash constituents . . . 5
Mineral theory 5
Nitrogen of the soil and atmosphere insufficient . . 6
Ammonium-salts with ash constituents 6
Organic manures unnecessary . 6
Silica unnecessary . . . 7
Artificial supply of nitrogen essential for wheat . . 7
Manures best for cereals . . 7
Excessive dressings unprofitable 7
Corn and straw from high manuring 7
Ammonium-salts alone . . 8
Natural supplies of ash and nitrogen 8
Soils better supplied with ash than with nitrogen . . 8
Importance of ash constituents 8
Ammonia with individual ash constituents 9
Relative importance of the ash constituents 9
Effect of autumn and spring applications of ammonium-salts 9
Spring sowing preferable . . 10

PAGE

Rainfall and time of sowing manure 10
With nitrate of soda . . . 10
Nitrate of soda excels ammonium-salts . . . 11
Influence of rainfall . . . 11
Proportion of corn to straw . . 12
Influence of season . . . 12
Influence of light and heat . 12
Autumn and winter weather . 13
Conditions favourable to large crops 13
Ash constituents and the seasons 13
Effects of residues of manures . 13
Residues of previous manuring 13
Tracing the fate of manures . 14
Loss of nitrates in drainage-waters 15
Loss of other manurial elements in rain-water . . . 16
Evidence of analyses . . 16
Natural restoration of nitrogen 16
Residues of nitrogen not accounted for 17
The fate of mineral constituents . 17
Behaviour of lime in the soil . 18
Continuous growth of barley—
Manures applied 19
Maintenance of yield under the continuous growth of barley on the same land 19
Effect of nitrogenous manures . 19
Effect of mineral manures . . 20
Relation of manuring to quality . 21
Effects of season upon yield and quality 21
Relative effects of weather and manures 22
Grass for hay—
Effect of manures upon the nature of the herbage 24
The unmanured plots . . . 24
Use of nitrogenous manures alone 24
Mineral manures used alone . 26
Complete manures—nitrogen and minerals 26

Changes in the herbage following changes in manuring . . 27
Effect of lime 27
Root crops—
Continuous growth of mangel-wurzel 28
Value of farmyard manure for mangel-wurzel 29
Effect of nitrogenous manures on mangel-wurzel 30
Effect of potash salts upon mangel-wurzel 30
Proportion of manure recovered in crop 31
Effect of manures upon the tilth of the soil 31
Manures and the incidence of disease 32
Other experiments at Rothamsted . 32

Highland and Agricultural Society's Experiments.

Object of the experiments . . 33
The stations 33
Manures tried 33
Cropping 33
Manures for turnips and beans . 33
Manures for cereals 34
Results with phosphatic manures—
Produce of dry matter from Pumpherston 34
Conclusions 34
Insoluble phosphates 34
Fineness of grinding 35
Phosphatic guano 35
Bone-meal 35
Soluble phosphates 35
Fine powdery condition essential 35
Insoluble phosphates for mossy land, &c. 35
Bones and fineness of grinding . 35
Nitrogenous manures—
Produce of dry matter at Pumpherston 35
Nitrate of soda 35
Sulphate of ammonia 36
Insoluble nitrogenous manures—
Rape-cake dust 36
Dried blood, horn-dust, &c . . 36
Potash manures 37
Manuring turnips 37
Forced turnips of bad quality . 37
Manures for rich crops of turnips 37
Manures for the barley crop . . 37
Nitrogenous manure for barley . 37
Phosphatic manures for barley . 38
Potash for barley 38
Manures for oats 38
Manures for the bean crop . . 38
Lessons from incomplete manure experiments 39
Potash alone 39
An experiment for farmers . . 40
Manures for different crops . . 40
Forms of manures for turnips . 40
Forms of manure for cereals . 40
Forms of manure for beans . . 40
Dung for turnips, cereals, and beans 40
Organic matter 40
Consider soil as well as manure and crop 41
Function of organic matter . . 41
Quick-acting manures and organic matter 41
Other research work 41

Experiments by the Royal Agricultural Society of England.

Woburn experimental farm . . 42
Pot-culture station, institution of . 42
The staff 42
Objects of the Woburn experiments 42
Scope of the work 42
Stackyard field 43
Continuous growing of wheat and barley 43, 44
Practical conclusions 45
The rotation experiments . . 46
Hellriegel's discoveries . . . 47
A change in plan 47
Green-manuring experiments . . 47
Other experiments with corn crops . 48
Experiments with potatoes . . 49
Experiments with mangels . . 49
"Finger-and-toe" in turnips . . 49
Experiments with clover . . 49
Experiments on lucerne . . . 49
Pasture experiments 49
Introduction of new crops . . 50
Ensilage experiments 50
Feeding experiments 50
Losses with farmyard manure . 50
Pot-culture station, work in . . 50

Aberdeenshire Experiments.

The experimental stations . . 51
Size of plot 51
Discussion as to size of plot . 52
Duplicated plots 52
Adjusting the manures . . 52
First year's conclusions . . 52
Condensed results 53
Insoluble phosphates as plant-food 53
The bearing of the new doctrine . 53
Experiments of subsequent years . 54
Relative value of phosphates and nitrogen 54
Final conclusions 55
Duplicate trials in England . . 55
Outside confirmation 56
The test of time 56
Effects of the Aberdeenshire experiments 56

Other Experiments 56

THE SEASONS—WEATHER AND WORK.

The agricultural year 57

Spring.

Field operations and spring weather 57
Early rising and the joys of spring 57
Cares of stock-owners in spring . 57
Field-work in spring . . . 58
The farmer's duties in spring . 58
Weather in spring . . . 58
Spring winds 58
Snow in spring 59
Rain in spring 59
Evaporation in spring . . . 59
Birds in spring storms . . 59
Cottage gardening . . . 59
The farmer's garden . . . 59
Fat cattle 59
Grass parks 59
Advantages of having field-work well advanced 60
Keep the plough going . . 60
Neglected work inefficiently done 60
Subdivision of farm-work . . 60
Advancing field-work . . . 60
Spring preliminaries . . . 61
Evils of procrastination . . 61

Summer.

The weather 61
Atmospherical complications in summer 61
Beneficial influence of dew . . 62
Summer rain 62
Light 62
Summary of summer farm-work—
Calendar and agricultural seasons 62
Root-sowing 63
Fat cattle 63
Fat sheep 63
Repairing fences 63
Grazing stock 63
Horses 63
Haymaking 63
Weaning lambs 63
Forage crops 63
Dairying 63
Weeds 63
Insect attacks 63
Top-dressing 63
Hours of labour 63
Rest 64
The farmer's duties . . . 64
The farmer's holiday . . . 64

Autumn.

Autumn weather and field operations—
Rewards of labour . . . 65
Rain in autumn 65
Autumn work—
Harvest 65
Weather and harvest . . . 65
Magnitude of harvest-work . . 65
Autumn anomalies 65
Field-sports 65
Autumn cultivation . . . 65
Autumn crops 66

Winter.

The weather, and field operations in winter—
Work in the steading . . . 66
Field work 66
Water-channels in ploughed land 66
Ploughing lea 66
Best season for draining . . 66
Planting hedges 66
Water-meadows 66
Feeding stock 67
Threshing grain 67
Sheep on turnips 67
Attention to ewes . . . 67
Marketing grain 67
Carting manure 67
Implements used in winter . . 67
Winter recreation . . . 67
Winter hospitality . . . 67
Domestic enjoyment . . . 68
Weather in winter . . . 68
Winter rain 68
Cold and frost 68
Beneficial influence of frost . . 68
Plants uprooted by frost . . 68
Snow 69
Snow keeps land warm . . 69
Snow-water and rain . . . 69
Uses and drawbacks of snow . 69
Hoar-frost 69
Injury by hoar-frost . . . 69

SEEDS OF THE FARM AND THEIR IDENTIFICATION.

General—
The nature of farm seeds . . 70
The size of seeds 70
Form and surface of "seeds" . 70
Examination of seeds by microscope and by pocket lens . . 70
Colour and gloss 71
Impurities in farm seeds . . 71
Adulteration and deterioration . 71
Parasites 72
Special—
Classification of farm seeds . . 72
True seeds—
The globular-seeded cruciferous plants 73
The kidney-shaped seeds of the chickweed family . . . 73
Leguminous seeds . . . 74
The two-faced rib-grass seeds . 77
Fruits—
The flat-beaked "seeds" of buttercups 77

The three-faced "seeds" of the dock family 78
The flat and beaked "seeds" of the dock family . . . 78
"Seeds" of composites . . . 79
Mericarps—
Umbelliferous "seeds" . . 80
"Seeds" of the Cleavers family . 81
Nutlets 81
Multiple fruits 82
Grass "seeds 82
(*a*) The "seed" the whole spikelet 82
(*b*) The "seed" the whole spikelet except the chaff (glumes) . 84
(*c*) The "seed" a portion of the spikelet with stalk on upper face; back rounded . . . 85
(*d*) The "seed" a portion of the spikelet; back V-shaped . 87
(*e*) The "seed" a portion of the spikelet with the back or base awned 88
Seeds of parasites 89

CORN CROPS.

Corn-growing 89
British resources for corn production 90

Varieties of Corn.

Wheat—
Simple classification . . . 91
Colour of wheat 91
Classification by the ear . . 91
Classifying by the grains . . 92
Relation of ear and grain . . 93
Vilmorin's classification . . 93
Judging wheat 93
Wheat for flour 93
Wheat varying with soil . . 94
Weight of wheat 94
Number of grains in a bushel . 94
Wheat for seed 94
Preserving wheat in granaries . 94
Ancient practice in storing . . 95
Storing *v.* immediate selling . 95
Quantity of ash in an acre of wheat 95
Kernel and husk 95
Origin of wheat 95
Antiquity of wheat cultivation . 95
Limits of wheat culture . . 95
Barley—
Classifying by the ear . . . 96
Classifying by the grain . . 96
Judging barley 97
Yield and weight of barley . 97
Grains in a bushel . . 97
Utilisation of barley . . . 97
Barley-meal 97
Malting 97
Limits of barley culture . . 97
Oats—
Classification by the grain . . 98
Classification by the ear . . 98
Yield and weight of oats . . 99
Grains in a bushel . . . 99
Kernel and husk 99
Oatmeal 99
Yield of meal 100
Composition of oatmeal . . 100
Oats as food for stock . . . 100
Antiquity of oat culture . . 100
Origin of the oat 101
Limits of oat culture . . . 101
Rye—
Yield and weight of rye . . 101
Limits of rye culture . . . 101
Rye-flour 102

Straw.

Wheat-straw 102
Ash of wheat-straw . . . 102
Barley-straw—
Ash 103
Strength of straw . . . 103
Oat-straw—
Ash 103
Chaff as a foot-warmer . . 103
Rye-straw 103
Ash of straw 104
Yield of straw 104
Ancient uses of straw . . . 104

Cross-Fertilisation of Grain.

Degeneracy of grain . . . 104
Mr Knight's efforts 105
Mr Raynbird's experiments . . 105
Mr P. Shirreff's experiments . 105
Other experiments 105
Process of cross-fertilisation . . 105
Organs of fructification . . 105
Details of the process . . . 106
Time of natural fecundation . 107
Good weather essential . . 107
Period for crossing . . . 107
First year usually satisfactory . 107
Time required to fix type . . 107
Percentage of success . . . 108
Protecting the ears . . . 108
After culture 108
Messrs Garton's work as hybridisers 108
Progress of hybridisation . . 109
Mendel's laws and the improvement of grain 110
Wheat breeding on Mendel's principles 110
Inheritance of beard and length of ear 110
New types 112
How to pick out fixed types . 112
Inheritance of other characters 112
Definition of strength . . 113
A strong parent 113

Inheritance of strength . 113
New types 113
Damage due to rust . . . 113
A rust-proof parent . . . 114
Inheritance of immunity . . 114
Possibilities of further work . 114

SOWING CEREALS.

Seed-time—
Seasonable working of land . . 115
Selecting seeds 115
Improvement in seeds . . . 115
Buy seeds in good time . . 115
Change of seed 115
New varieties of farm plants . 116
Testing seed 116
Sowing wheat in autumn—
Fallow wheat 117
Ploughing for wheat . . . 117
Grubbing for wheat . . . 117
Advantages of grubbing . . 117
New or old seed 117
Time for sowing 118
Quantity of seed for wheat . . 118
Variety to sow 118
Water-courses 118
Harrowing 118
Frost throwing out plants . . 118
Rolling 118
Wheat after beans . . . 119
Wheat after potatoes . . . 119
Wheat after grass . . . 119
Sowing wheat in spring—
Land for spring wheat . . . 119
Date of spring sowing . . . 119
Tillage for spring wheat . . 120
Double-furrow plough . . . 120
Advantages of the double-furrow plough 120
Sowing operations—
Placing sacks in the field . . 120
Where to begin sowing . . 121
Seed carrier 121
Seed-basket 121
The seed-sacks 121
One-hand sowing 121
Two-hand sowing . . . 122
Art of sowing 122
Sowing-machines 123
Broadcast sowers 123
Drill sowers 124
Width of drill 124
Hand seed-drill 124
Hand broadcast sowers . . 124
Harrowing—
Iron harrows 125
Process of harrowing . . . 125
Cross-harrowing 126
Efficient harrowing . . . 126
Water-furrows 126
Under-drainage *v.* water-furrows . 127
Wheat after grass . . . 127
Varieties of spring wheat . . 127
Spring wheat-seed from early districts 128
Late varieties of wheat . . 128
Manuring wheat 128
Summer culture of wheat . . 128
Autumn wheat 128
Over-luxuriance in autumn wheat 128
Cropping rank wheat . . . 129
Soil and over-luxuriance . . 129
Weeding 129
Hoeing drilled wheat . . . 129
Top-dressing wheat . . . 130
Flowering season 130
Pickling wheat 130
Turning pickled wheat . . 131
Sowing barley—
Tillage for barley 131
Sowing 132
Quantity of seed 132
Germination of barley and the weather 132
Harrowing for barley . . . 132
Finishing 133
Soil for barley 133
Varieties of barley . . . 133
Uses of barley 133
Manuring barley 133
Rothamsted barley experiments—
No manure 133
Farmyard dung 133
Mineral manures 133
Nitrogenous manures . . . 134
Nitrogenous and mineral manures combined 134
Practical conclusions . . . 134
Barley after corn 134
Quality of barley after roots . 134
Superphosphate for barley . . 134
Yorkshire trials in manuring barley 135
Summer culture of barley . . 135
Destroying charlock . . . 135
Top-dressing barley . . . 136
Sowing oats—
Varieties of oats 136
Sowing 136
Harrowing before sowing . . 136
Quantity of seed 137
Number of seeds per acre . . 137
Harrowing after sowing . . 137
Water-furrows 137
Machine-sowing 137
Ploughing for oats . . . 137
Thick and thin sowing . . 138
Sowing mixed varieties . . 138
Oats and barley mixed . . 138
Manuring for oats 138
Welsh trials in manuring oats . 138
Summer culture of oats . . . 139
Influence of season and soil on varieties of oats 139
New and old varieties of oats compared 140

The milling properties of oats . . 140
Effect of soil on milling property . 141
Sowing rye 141
Rolling land 141
Diameter and weight of rollers . 142
Divided roller 142
Water-ballast roller 143
Process of rolling 143
Speed in rolling 143
Time for rolling 143
General principles of corn culture . 144
Cross-ploughing land 144
Harrowing before cross-ploughing 144
System of cross-ploughing . . 145
Ploughing ridges and feerings . 146
Depth of cross-furrow 146

BEANS AND PEAS.

Beans—
Field-bean 146
Leguminous plants 146
Beans containing poison . . 147
Yield and weight of beans . . 147
Consumption of beans . . . 147
Peas 147
Produce of peas 148
Consumption of peas 148
Bean- and pea-straw 148
Sowing beans—
Varieties of beans 149
Quantity of seed 149
Manure for beans 149
Beans and nitrogenous manure . 149
Ploughing for beans 150
Spring tillage for beans . . 150
Cultivators and grubbers . . 150
Sowing autumn-manured beans . 150
Sowing spring-manured beans . 151
Harrowing drills 152
Summer culture of beans—
Horse-hoeing 152
Hand-hoeing 152
Rows on the flat 152
No harbour to weeds 152
Broadcast 152
Cropping beans 152
Beans and peas mixed . . . 153
Botanical character of beans . 153
Ancient notions regarding beans . 153
Sowing peas—
Tillage for peas 153
Sowing peas 154
Sowing peas in autumn . . 154
Summer culture of peas . . . 154

GERMINATION OF SEEDS.

Conditions essential for germination 155
Air and germination 155
Moisture and germination . . 155
Composition of seeds 156
Changes incidental to germination . 156
The embryo 156
The young plant or seedling . . 156
Seed dissected 157
Multiple stems or "tillering" . . 157
Different methods of sowing and germination—
Disadvantages of broadcast sowing 157
Advantages of drill sowing . . 159
Dibbling 159
Waste of seed 159
Waste of seeds by different methods of sowing . . . 160
Tillering after rain 161
Quantity of seed 161
Produce from different methods of sowing 161
Importance of economising seed . 161
Thick and thin sowing . . . 161
Different methods of sowing compared 162
Dibbling-machines 163
Deep and shallow sowing . . 164
Tillering 165
Destruction of seed 166
Transplanting 166

GRAIN HARVEST.

Beginning of harvest 167
Stage for cutting—
Loss by too early cutting . . 167
Ripening in the sheaf . . . 167
Shedding or "shaking" . . . 168
Barley 168
Happy medium 168
Ripening process 168
Judging ripeness 168
Degrees of ripeness 169
Harvest labour 169
Reaping appliances 169
Sickle or "hook" 169
Form of sickle 169
Toothed sickle 169
Smooth-edged sickle 169
Sickle still used 170
Thraving 170
Scythe—
Hainault scythe 170
Common scythe 171
Cradle 171
Setting a scythe 171
Iron scythes 171
Straight sned 172
Sharpening scythes 172
Method of scythe-reaping . . 172
Speed with the scythe . . . 172
The reaping-machine—
Historical 172
Ancient machine 172
Nineteenth-century machines . 172
First effective reaping-machine . 172
Bell's reaping machine . . 172
Construction 173

Work done 173
Cost of reaping 173
Slow process of Bell's reaper . 174
American machines . . . 174
Dray's Hussey machine . . 174
M'Cormick's reaping-machine . 174
Modern reaping-machines—
Varieties of machines . . 175
Draught 175
Price 175
Perfect workmanship . 175
Speed 175
Force employed . . . 175
Cost of reaping . . . 175
Manual and self-delivery machines—
Side-delivery reapers . . 176
Manual *v.* self-delivery reapers 176
Self-binder—
General construction . . . 177
Efficiency of the binder . . 177
The Hornsby binder . . . 177
Cutting the crop . . . 177
Elevating 178
Elevator and platform rails . 178
Conveyor-roll 178
Binding 178
Needle 178
The knotter 178
Delivery of sheaf . . . 178
At work 180
Speed 180
Other binders 180
Progress of the binder . . . 180
Working the binder . . . 181
Speed in cutting round . . 181
Hands required . . . 181
Raking 181
Size of sheaves 181
Cost of cutting with binder and reaper—
Saving in labour . . . 181
Saving in crop 181
Examples of cost . . . 181
Harvesting by motor . . . 182
The stripper harvester . . . 182
Process of reaping 182
Reaping oats—
Preparing to cut 182
Sharp knives 182
Cutting "roads" 183
Cutting 183
Force of labour 183
Raking 184
Other methods 184
Detecting bad work . . . 184
Arranging the force for manual-delivery reapers . . . 184
Bands and binding 184
Method of binding . . . 184
Size of sheaves 185
Lifting broken stalks . . . 185
Raking 185
Drying rakings 185
Stooking or shocking . . . 185
Stooking 186
Direction of stooks . . . 186
Placing the band-knots . . 186
Size of stooks 186
"Pirling" 186
Hooding 187
"Gaiting" 187
Reaping barley—
Quick drying 187
Small sheaves 187
Reaping wheat—
Scythe unsuitable . . . 188
Reaping-machines . . . 188
Self-binders 188
Time to cut wheat . . . 188
Sheaves for wheat . . . 188
Wheat stooks 188
Hooding 188
Stacking cereals—
Time for drying 189
Judging of dryness . . . 189
Weather and drying . . . 189
Sprouting 189
Process of stacking—
Temporary stacking or "rickling" 189
Advantages of "rickling" . . 189
Preparing for stacking . . . 189
Cart frames 190
Harvest cart 190
Farm waggon 191
Harvest forks 191
Cart-ropes 191
Care of ropes 191
Forking 191
Injury to young grass . . . 192
Order in forking sheaves . . 192
Carting "gaitins" . . . 192
Loading a cart 192
Roping loaded carts . . . 192
Hours of carting 192
Commencing stack-building . 193
Arranging a stackyard . . . 193
Foundation for stacks . . . 193
Process of stack-building . . 193
Size of stack 194
Second forker 194
Trimming stacks 194
Form of stack 194
Height of stack 195
Eave 195
Topping stacks 195
Process of thatching—
Stack-ropes 195
Straw-rope making . . . 195
Straw for ropes 196
Winding straw-ropes . . . 196
Thatching 196
Material for thatch . . . 196
Drawn straw 196
Thatch-making machine . . 197
Method of thatching . . . 197
Forming the apex . . . 197

Roping stacks 198
Lozenge roping 198
Number of ropes 198
Tying ropes 198
Another method of roping . . 198
Round tops 199
An English custom . . . 199
Finishing stacks 199
Cutting thatch 200
Stack-heating—
Barley 200
Injury from heating . . . 200
Remedy 200
Symptoms of heating . . . 200
Oats 200
Wheat 200
Partial heating 200
Propping stacks 200
Stack ventilators—
Common boss 201
Prismatic boss 201
Other methods 201
Measuring heat in stacks . . 201
Improved ventilator . . . 201
Field stacks 202
Artificial drying—
Hot-air drying 202
Nelson system 202
Drying racks 202
The Richmond grain-drying rack 202
Filling the rack . . . 206
Contents 207
Advantages of the rack . . 207
Cost 207
Convertible into a shed . . 207
Grain-drying shed . . . 207
Other racks 208

HARVESTING BEANS, PEAS, AND TARES.

Beans 208
Peas 209
Tares or vetches 209
Stacking peas and beans—
Peas 209
Beans 209
Thatching peas and beans . . 209
Reaping backwheat 209
Cutting 210
Drying 210

CORN AT THE STEADING.

Threshing-machines—
An ancient threshing-machine . 210
Scottish threshing-machine . . 211
Saving of labour 212
Portable threshing-machines . 213
Hands required for threshing-machines 213
Safety-drums 215
Straw-trusser 215
Hand threshing-machines . . 216
Motive power for threshing-machines 216
Steam-power 216
Water-power—
Undershot water-wheels . 217
Bucket water-wheel . . . 217
Measuring the water-supply . 217
Horse-power in a stream . . 218
Mill-dam 218
Forming mill-dam . . . 218
Dimensions of the bucket-wheel 218
The arc 218
Construction of the wheel . 219
Overshot or breast? . . . 220
Trough and sluices . . . 220
Speed of the wheel . . . 221
The turbine 221
Horse-power 221
Threshing and winnowing corn—
Ladders 222
Preparing for threshing . . 223
Care in feeding 223
Irregular driving 223
Removing straw 223
Dressing corn—
Modern winnowers . . . 224
Corn-screens 225
Barn implements 225
Riddles 225
Sieves 226
Barn wechts or baskets . . 226
Barn-hoe 226
Corn-shovels 227
Barn-brooms 227
Measuring grain 227
Bagging grain 228
Hummellers 228
Tying sacks of corn . . . 228
Lifting sacks of corn . . . 228
Loading a cart with sacks . . 229
Corn-sacks 229
Sack-barrow 230
Weighing-machines . . . 230

GRASSES AND CLOVERS.

Varieties of grasses—
Agrostis alba — var. *stolonifera* (fiorin) 231
Alopecurus pratensis (meadow fox-tail) 231
Anthoxanthum odoratum (sweet-scented vernal) . . . 231
Avena flavescens (yellow oat-grass) 232
Avena elatior (tall oat-grass) . 233
Cynosurus cristatus (crested dogs-tail) 233
Dactylis glomerata (rough cocksfoot) 233
Festuca pratensis (meadow fescue) 234
Festuca elatior (tall fescue) . . 235
Festuca heterophylla (various-leaved fescue) 235
Festuca ovina tenuifolia (fine-leaved sheep's fescue) . . 236

Festuca duriuscula (hard fescue) . 236
Festuca rubra (red fescue) . . 236
Glyceria fluitans (floating sweet grass) 237
Lolium perenne (perennial rye-grass) 237
Lolium italicum (Italian rye-grass) 238
Phleum pratense (timothy or meadow catstail) 239
Poa pratensis (smooth-stalked meadow-grass) 239
Poa trivialis (rough-stalked meadow-grass) 240
Poa nemoralis sempervirens (evergreen meadow-grass) . . 240
Poa aquatica (water meadow-grass) 241
Varieties of clovers—
Importance of the clovers . . 241
Soils and climate for clovers . 241
Clover seed 241
Perennial red clover . . . 242
Meadow trefoil 243
Creeping trefoil 243
White clover 243
Alsike clover 243
Trifolium incarnatum . . . 243
Impurities in clover . . . 244
Varieties of grasses sown . . 244
Seeds for rotation grasses . . 244
Grasses and clovers for permanent pasture 245
Grasses for different soils . . 245
Standard seed mixtures . . 246
Mr De Laune's mixtures . . 246
Sowing grass seeds—
Time of sowing 247
Depth for grass seeds . . . 247
Methods of sowing . . . 248
Hand-sowing 248
Machine-sowing 248
Speed of the sowing-machine . 248
Grass-seed harrows . . . 248
Working wide harrows . . 249
Harrow carriage 249
Rolling for grass seeds . . . 249
Crops accompanying grass seeds . 250
Harrowing the wheat-braird . 250
Sowing with spring crops . . 250
Frost injuring clover seeds . . 250

THE HAY CROP.

Varieties of hay 251
Tillage for hay 251
Manuring the hay crop . . . 251
Manuring rotation hay . . 251
Manuring meadow hay . . 251
English trials in manuring meadows 252
Trials in Yorkshire . . . 252
Reading trials 252
Trials in Wales 252
Yield of hay 253
Aftermath 253
Haymaking—
Object of haymaking . . . 253
Weather and haymaking . . 253
Cutting hay—
Time for cutting hay . . . 253
Hay for seed 253
Hay for feeding 254
Best stage for cutting . . . 254
Aftermath 254
Premature cutting . . . 254
Study the weather . . . 254
Hay injured by wet . . . 254
Hot and cold rain . . . 255
Cutting rotation hay . . . 255
Cutting early and late grasses . 255
Ill-suited mixtures . . . 255
Clover, sainfoin, and lucerne . 255
Preparing to cut . . . 255
Methods of cutting—
Mowing-machine 256
Close cutting 256
Sharp knives 256
Mower *v.* scythe 256
Types of mowers 256
All-round or side cutting . . 257
Laid patches 257
Cutting laid crops . . . 257
Direction to cut 257
Clearing swathe ends . . . 258
Head-ridges 258
One-way cutting 258
Loosening lumps 258
Difficulties with heavy crops . 258
"Making" the hay—
Variations in practice . . . 258
Grounds for variations . . 258
Haymaking controlled by weather 258
English methods 259
Meadow hay 259
Haymaking machines . . . 259
Swathe-turning and tedding . 259
Forward and backward tedding . 260
Experiments in tedding . . 260
Speedy haymaking . . . 260
Tedding with high wind . . 260
Tedders injuring clover hay . 260
Collecting hay 260
"Cocking" hay 261
Large and small "cocks" . . 261
Differences in methods . . 261
Scottish methods 261
Rotation hay 261
Turning clover hay . . . 261
Process of turning . . . 262
Fit for coiling 262
Methods of collecting the hay . 262
Coils or cocks 262
Forming coils 262
Well-made coils 263
Badly-made coils 263

Small coils 263
Remaking coils 263
Avoid over-working . . . 263
Timothy hay 263
Thunderstorms and haymaking . 263
Securing wet coils . . . 263
Hours for coiling . . . 264
Raking 264
Coiling in high wind . . . 264
Time for field-stacking . . 264
Temporary stacks . . . 264
Stack "kilns" or "bosses" . . 265
Situation of field-stacks . . 265
Hay-collector 265
Hay-sledge 265
Loading the sledge . . . 267
Unloading the sledge . . . 267
Other methods of hauling . . 267
American hay-collector . . 267
Preparing for stacking . . 268
Ground for stacks . . . 268
Work with the wind . . . 268
Building field-stacks . . . 268
Premature stacking . . . 269
Early *v.* late stacking . . . 269
Straw and hay mixed . . . 269
Haymaking by stages . . . 269
Hay-barns 270
Permanent hay-stacks . . . 270
Foundation of stacks . . . 270
Bosses or flues 271
Size of stacks 271
Force in building stacks . . 271
Process of building . . . 271
High-forking by hand . . . 271
Forking from different parts . 272
Heading stacks 272
Roping hay-stacks . . . 272
Form of stackhead . . . 272
Large stacks 273
Propping stacks 273
Height of stacks 273
Improved hay-stacking appliances—
Stack-lifters 273
Defect in the system . . . 273
Horse-forks 274
Types of horse-forks . . . 274
Clip-fork 274
Elevating apparatus . . . 274
Hay elevator 275
Advantages of the horse-fork . 275
A good day's work . . . 275
Horse-fork working in sheds . 275
Horse-forks for small farmers . 276
Dressing stacks 276
Irish methods 276
Rick-cloths 277
Salting and spicing hay . . . 277
Growing rye-grass seed . . . 278
Methods of growing and handling rye-grass seed 278
Yield of rye-grass seed . 278
The flail for threshing rye-grass . 278
Artificial hay-drying—
Hot air and Neilson systems . 278
Pressing hay 279

THE MANAGEMENT OF PASTURES.

Insufficient attention to pastures . 280
Pastures on different soils . . 280
Effect of climate on pastures . . 280
Pastures should not be mown . . 280
The prospects of profit from pastures 281
Drainage of pastures . . . 281
Manuring of pastures . . . 281
Feeding cake on pastures . . 282
Caution in using cakes on pastures 282
Suggested dressings of manures . 282
Application of manures . . 283
Stocking of pastures . . . 283
Water-supply 284
Weeds 284
Drains and fences 284
Grazing after a hay crop . . . 284
Value of pastures 284

FORMATION OF PERMANENT PASTURE.

Grasses and clovers for permanent pasture 285
Trials in Northumberland . . 285
Trials in Cumberland . . . 285
Wild white clover . . . 286
Trials in south of England . . 286
Local circumstances to be considered 286
Sowing permanent pastures—
Sowing grass seeds without another crop 286
Sowing grass with another crop . 286
Hay crop from permanent grasses 287
Early grazing of permanent grass 287
Manures for permanent pasture . 287
Fairy rings in pastures . . 287
Clifton Park system of growing grass 287
Permanent pasture on poor clay soil 288

ENSILAGE.

History of ensilage 289
Introduction into Great Britain . 289
Silos 290
Silos, above or below ground? . 290
Concrete silos 290
Silo with lever-pressure . . 290
Wooden silos 290
American and Canadian silos . 290
Methods of pressure . . . 290
Stack ensilage 290
Sweet and sour silage . . . 291
Making sweet silage . . . 291
Analyses of sweet and sour silage 291
Pressure for ensilage stacks . 291
Crops for silage . . . 292
Feeding value of silage . . . 293
Hay *v.* silage 293

Advantages claimed for ensilage . 293
Ensilage losing in favour . . 295

THE POTATO CROP.

Varieties of potatoes . . . 295
Introduction into Europe . . 295
Distribution of the potato . . 296
Varieties in use 296
Good potatoes 296
Potato disease 296
Soil and tillage for potatoes—
Land for potatoes . . . 296
Tillage for potatoes . . . 296
Manuring potatoes 297
Dung for potatoes . . . 297
Mechanical influence of dung on potatoes 297
Typical dressings . . . 297
Quickly acting manures for potatoes 297
Dr Aitken on manuring potatoes . 298
Form of manures for potatoes . 298
Nitrogen for potatoes . . . 298
Potash for potatoes . . . 298
Too much potash injurious . . 298
Proportion of manurial ingredients 298
Rothamsted experiments with potatoes—
Farmyard dung 299
Dung and superphosphate . . 299
Dung, superphosphate, and nitrate of soda 299
Artificial manures . . . 299
Conclusions 299
Slow exhaustion of dung . . 299
Residue of dung 300
Sir Henry Gilbert on dung for potatoes 300
A practical lesson . . . 300
Potash for potatoes . . . 300
General observations on manuring potatoes 301
College trials in manuring potatoes 301
Application of manure for potatoes—
Autumn dunging . . . 301
Spring tillage with autumn dunging 302
Spring dunging 302
Carting dung for potatoes . . 302
Filling dung 302
Distributing dung from carts . 303
Spreading dung 303
Sowing artificial manure . . 303
Planting potatoes—
Potato-seed 303
Preserving sets 304
Quantity of seed per acre . . 304
Planting on the flat . . . 304
The drill system 304
Single *v.* drill plough . . . 304
Planting the seed . . . 305
Potato-planting machines . . 305
Conveying seed to the planters . 305
Covering in 306
Complete planting as it proceeds 306
Danger of leaving dung and seed uncovered 306
An Ayrshire practice in potato planting 306
Width of potato-drills . . . 307
Depth of sets and distance apart. 307
Time for planting potatoes . . 307
Experiments with late planting . 307
Culture after planting . . . 307
Hand-hoeing 307
Planting potatoes in autumn—
Autumn planting unsuitable . 308
Method of autumn planting . 308
Seed for autumn planting . . 308
The boxing system of preparing potato-sets 308
Boxes 308
Tubers boxed 308
Cut seed unsuitable . . . 309
Boxing the seed 309
Storing boxes 309
Planting boxed seed . . . 309
Seed per acre 309
Advantages of the system . . 309
The lazy-bed system . . . 310
Raising new varieties of potatoes—
New varieties resisting disease . 310
Potato-seeds 311
Seedless varieties. . . . 311
Cross-fertilisation . . 311
Male and female organs . . 311
Process of cross-fertilising . . 312
Marking fertilised plum . . 313
Ripe plums 313
Securing and storing seeds . . 313
Sowing the seed 313
The young seedlings . . 313
Lifting and selecting . . . 314
Storing seedling potatoes . . 314
Period of development . . 314
Second year 314
Third year 314
Retain only superior varieties . 314
Need for new varieties . . 315
Raising potatoes—
Time to lift potatoes . . . 315
Methods of potato-raising . . 315
Raising early potatoes . . . 315
Raising by the graip . . . 315
Barrels for early potatoes . . 315
Preparing barrels . . . 316
Filling barrels 316
Handling barrels . . . 316
Speedy marketing . . . 316
Small potatoes 316
Medium-sized potatoes . . 316
Disease 316
Raising late or main-crop potatoes . 316
Potato-digger 317
Speed of potato-diggers . . 317
Preparing for the digger . . 317

Gatherers required . . . 317
Arranging the gatherers . . 317
Assorting potatoes . . . 317
Harrows following digger . . 317
Collecting carts 318
Diseased tubers 318
Tubers free from earth . . 318
Process of digging . . . 318
One-way digging 319
Horses required 319
Adjusting the digger . . . 319
Depth of digging 319
Adjusting the sock . . . 319
Adjusting force of labour . . 320
Second harrowing . . . 320
Weather and digging . . . 320
Plough digging 320
Potato-plough 320
Digging by drill-ploughs . . 320
Harrowing 321
Forking after ploughs . . . 321
Improved digger best . . . 321
Storing potatoes—
Supplies of early potatoes . . 321
Potatoes difficult to preserve . 321
Field pits 321
Prismatic pit 322
Conical pit 322
A Yorkshire method . . . 322
Ventilating pits 323
Heating 323
Seed pits 323
Storing wet potatoes . . . 323
Potato-shaws as thatch . . 323
Frosted potatoes 323

THE TURNIP CROP.

Advantages of the turnip crop . 324
Turnip-growing may be overdone 324
Introduction of turnips . . . 324
Varieties of turnips. . . . 325
Swedes 325
Common turnips 325
New varieties 325
Produce of different varieties . 325
Climatic influences on turnips . 326
Insect attacks 326
Proportion of leaf and root . . 326
Order of using turnips . . 326
Ill-shaped turnips 326
Number of turnips per acre . . 327
Careful and careless thinning of roots 327
Specific gravity of turnips . . 327
Distribution of the turnip . 327
Soils for turnips 328
Clay soils unsuitable for turnips . 328
Tillage of land for turnips—
Variety of systems . . 328
Soil, climate, and system of tillage 329
Prevailing system . . . 329
Normal conditions . . . 329
Autumn and winter ploughing. 329
Spring tillage 329
Ploughing or grubbing . . 330
Pulverising ploughs . . . 330
Harrowing turnip land . . 330
Removing weeds . . . 330
Exceptional conditions . . 331
Preparing foul clay land . . 331
Autumn cleaning . . . 331
A second crop of weeds . . 331
Do not break weeds . . . 332
Cross-cultivation . . . 332
Steam-power for cleaning clay land 332
Half-ploughing 332
Autumn dunging and ploughing 332
Spring tillage of strong land . 332
Grubbing or cultivating in spring 332
Preparing clean land . . . 333
Spring tillage of light clean land 333
Overworking injurious . . 333
Forking out weeds . . . 333
Turnips on very strong clays . 333
Sowing turnips—
Introduction of drill sowing . 334
Turnips in raised drills . . 334
Disadvantage of raised drills . 334
Advantages of raised drills . . 334
Width of drills 334
Drill-plough 334
Depth of the drill . . . 335
Raised drills on strong clays . 335
Drilling on the flat . . . 335
Width of rows 335
Broadcast sowing of turnips . 335
Dunging and sowing in raised drills 336
Simultaneous drilling and sowing 336
Stale seed-bed undesirable . 336
The force employed . . . 336
Arranging the force . . . 336
Opening and closing drills . 337
Another method . . . 337
Turnip seed drill . . . 337
Drilling manure and seed . 337
Water drill 337
Consolidating the drill-top . 337
Drill for sowing on the flat . 338
Water and dry drills compared 338
Manure injuring seeds . . 338
Time of sowing 338
Quantity of turnip seed . . 338
Thick and thin sowing . . 338
Selection of turnip seed . . 338
Depth for turnip seed . . 339
Manuring turnips—
Dependence upon manure . . 339
An exhausting crop . . . 339
Elements absorbed by roots . 340
Elements to be supplied in manure 340
Subordinate elements . . . 340
Uncertainties in manuring . . 340

Nitrogen, potash, and phosphoric acid for turnips . . . 341
Chief manure for turnips . . 341
Nitrogen for turnips . . . 342
Atmospheric nitrogen for turnips 342
Nitrogen in the soil . . . 342
Rothamsted trials . . . 342
English practice . . . 342
Experiments with nitrogen at Carbeth 342
Potash for turnips . . . 343
An excess of potash injurious . 343
Test the soil 343
Phosphates for turnips . . 343
Too much reliance on phosphates 344
Superphosphate manuring exhausts the soil . . . 344
Recouping the soil . . . 344
Phosphates with dung . . 344
Phosphates without dung . 344
Cheapest phosphate for turnips 344
Mineral phosphates . . . 345
Discrimination in use of mineral phosphates 345
Superphosphates . . . 345
Climate and soil to be considered 345
Basic slag for turnips . . 346
Farmyard manure for turnips . 346
Supplementing dung . . 346
Is dung essential for turnips? 346
Quantities of manures for turnips 347
Yield and quantity of dung . 347
Scottish dressings . . . 347
Advantage of heavy dressings questionable 347
Moderate dressings of dung . 347
Artificial manures alone . . 348
Southern dressings . . . 348
Necessity for individual judgment 348
Application of manure for turnips 348
Carting dung into drills . . 348
Cart for steep land . . . 349
Dung-spreading apparatus . 349
Sowing artificial manure . . 349
Southern customs . . . 349
Top-dressing turnips . . 350
Experiments in the north of Scotland 350
Fine grinding in manures . 350
Basic slag *v.* superphosphate . 350
Experiments in the north of England 350
Experiments in the south of England 350
Manures preventing blanks . 351
Welsh trials. 351
Artificial manure alone . . 351
Singling and hoeing turnips—
Influence of weather . . . 352
Drill-harrowing or horse-hoeing . 352
Harrowing across flat rows . . 352
Drill-scarifier 352
Thinning-machines . . . 353
Hand-hoes 353
Process of hand-hoeing on raised drills 353
Hoeing-matches 353
Good and bad hoeing . . . 353
Hand-hoeing in flat rows . . 353
Speed of hoers 353
Thinning by hand 354
Transplanting turnip plants . 354
Distance between plants . . 354
Results from short intervals . 354
Prevailing intervals . . . 354
Growing roots in squares . . 355
Advantages of drills. . . 355
Medium and large roots . . 355
Moderate intervals . . . 355
Irregularity in growth of turnips 355
After cultivation 356
Care in hoeing strong plants . 356
Earthing-up turnips . . 366
Turnip pests . . . 356, 462
Storing turnips 356
Advantages of storing roots 356
Keeping properties of turnips 357
Time for storing swedes . . 357
When to store white turnips . 357
Turnips consumed on the ground by sheep 357
Quantity of roots to be left for sheep 357
Stripping turnips . . . 358
Turnip-tops as food . . . 358
Turnip-tops as manure . . 358
Turnip-lifting appliances . . 358
Mode of pulling turnips . . 359
Checking turnip-growth in spring 359
Turnip-lifters 360
Further hints to turnip-lifters . 360
Carting turnips 360
Lifters one yoking ahead of carters 360
Dry weather best for turnip-storing 360
Importance of storing roots . . 360
Methods of storing turnips . . 361
Thatching turnip-store . . 361
Turnip pits in the field . . 361
Taking roots from the store . . 361
Storing in furrows . . . 361
Temporary storing on lea . . 361
Storing in houses objectionable . 362
Storing in hurdle enclosures . 362
Storing turnips for ewes . . 362
Earthing-up turnips . . . 362

THE MANGEL CROP.

Varieties of mangels . . . 362
Climate for mangels . . 363

Soils for mangels 363
Cultivation for mangels 363
Autumn tillage 363
Spring tillage 363
Drills and flat rows 363
Mangel seed 363
Quantity of seed 364
Time of sowing 364
Manures for mangels—
Dependency on manure . . 364
Ingredients absorbed by mangels 364
Ingredients of manure for mangels 364
Rothamsted experiments — In manuring mangels . . 364
Salt for mangels 364
Useful dressings 365
Application of manure for mangels 365
Artificial manures . . . 365
Thinning and after cultivation—
Preliminary cleaning . . . 366
Thinning 366
After hoeing 366
Transplanting mangels . 366
Injuring mangel plants . . 366
Yield of mangels 366
Mangel plagues 366
Storing mangels 366
Cover with dry straw . . . 366
Pulling mangels 366
Carting roots 367
Method of storing mangels . . 367
Mangels stored in houses . . 367

FORAGE CROPS.

Importance of forage crops . . 368
Vetches 368
Winter vetches 368
Spring vetches 368
Utilising vetches 368
Vetches for horses . . . 368
Land for vetches 368
Seed 369
Cutting vetches 369
Manuring vetches . . . 369
Vetches and cleaning land . . 369
Lucerne 369
The crop for dry seasons . . 370
Sainfoin 370
Sainfoin hay 370
Rye 370
Cabbages 371
Early cabbages—
For spring use . . . 371
For summer use . . . 371
Late cabbages—
Sowing and planting . . 371
Cabbage plants . . . 372
Produce 372
Manuring 372
Utilising cabbages . . . 372
Cabbages and Italian rye-grass 372
Storing cabbages . . . 373
Lifting cabbages . . . 373
Utilising cabbage-stalks . . 373
Thousand-headed kale . . . 374
Transplanting kale . . 374
Consuming kale . . 374
Rape 374
Mustard 375
Sowing crimson clover . . . 375
Culture in England . . 375
As a forage crop . . . 375
Late variety 375
Extra late variety . . . 376
White variety 376
Italian rye-grass 376
Sowing for forage . . . 376
Seed 376
Produce 376
Irrigation crop 376
Other forage plants 376
Furze, gorse, or whin . . 376
Kidney-vetch 376
Maize and sorghum . . . 376
Prickly comfrey 376
Buckwheat 376

HOP CULTURE.

Varieties of hops 377
Male and female hops . . . 377
Soil for hops 377
Preparing land 377
Rearing hop plants 377
Planting hops 378
Cost of wiring 378
Dressing hop plants . . . 378
After culture 379
Manuring 379
Experiments in manuring hops . 380
Creasoting poles 380
Poling 381
Tying up the bines 381
Longevity of the hop . . . 381
Insect and fungoid attacks . 381, 456
Harvesting hops—
Picking 381
Price of picking hops . . . 382
Drying hops 382
Pocketing 383
Stacking poles 383
Analysis of hops 383
Spent hops as manure . . . 384
Cost of hop-planting and cultivation 384
Produce of hops 384

FLAX CULTURE.

Flax culture 384
Soil for flax 385
Rotation for flax 385
Tillage for flax 385
Clod-crushers 385

Norwegian harrow 386
Spring-tined cultivator 386
Sowing flax 387
Seed 387
Grass seeds with flax 387
Manuring flax 387
Weeding flax 388
Pulling, steeping, and drying flax—
Pulling 388
Method of pulling 388
Rippling 388
The bolls 389
Another method of harvesting . 389
Steeping or retting 389
Drying 390
Lifting 390
Scutching 390
Growing and saving seed . . 390
Yield 390
Selecting seed for sowing . . 390
Old seed 390
Flax-pond water 390
Flax-growing in Great Britain and Ireland 390
Former uses 391
Recent trials 391
Outlet for flax straw 391
Uses of flax seed 391
Uses of flax straw 391
Flax straw for paper-making . 391
Other methods of retting . . 392

SUBSIDIARY FARM CROPS.

Kohl-rabi 392
Advantages of kohl-rabi . . 392
Uncertain crop 393
Soil for kohl-rabi 393
Tillage and manuring . . . 393
Planting or sowing 393
Time for sowing 393
Thinning and hoeing . . . 393
Produce 393
Storing kohl-rabi 393
Cabbages 371, 393
Carrots 393
Carrot-tops as food for stock . 393
Analysis 394
Soil for carrots 394
Tillage and manuring . . . 394
Cleaning for carrots . . . 394
Sowing carrots 394
Preparing carrot seed . . . 395
Thinning carrots 395
Carrots and rye 395
Varieties 395
Produce 395
Storing carrots—
Liability to rot . . . 395
Time for storing . . . 396
Pulling 396
Carrot-leaves 396
Growing and heating in pits . 396
Carrot-pits 396
Carrot pests 396, 445
Parsnips 396
Storing parsnips 396
Parsnip-leaves as food for cows . 397
Market-gardening—
Dairying and market-gardening . 397
Savoys 397
Greens, cauliflowers, &c. . . 398
Carrots, parsnips, beetroot, and onions 398
Leeks 398
Manuring 398
Culture 398
Turnips for table use . . . 398
Turnip-tops 398
Beans and peas 398
Rhubarb 399
Strawberries 399
Irregular produce . . . 399
Planting 399
The fruit 399
Price 399
Duration of plants . . . 399
Labour and soil . . . 400
Bush fruit 400
Cost of planting . . . 400
Catch cropping . . . 400
Disease in black currants . 400
Gooseberries 400
Raspberries 400
Orchards 400
Flowers 401
Bulbs 401
Red-clover seed 401
Cutting and drying . . . 402
Threshing 402
Hemp culture 402
Lavender 402
Woad farming 403
Excise restrictions on cropping 403
Sugar-beet 403
Root-alcohol for industrial purposes 403
Tobacco 403
Aromatic herbs 404
Chicory 404
Electricity in agriculture . 404

THE FUNGUS DISEASES OF PLANTS.

The Phycomycetes 405
The "damping off" of seedlings . 405
Potato disease 406
Description and life-history . 406
Preventive and remedial measures 409
Warty disease of potatoes . 410
Onion mildew 411
White rust of crucifers . . 411
The Ascomycetes—
The mildews 411
Turnip mildew 411

Mildew of grasses . . . 412
Mildew of pea 412
Mildew of rose 412
Gooseberry mildew . . . 412
American gooseberry mildew . 412
Winter rot of potatoes . . 412
Ergot 414
Phoma 414
The Uredineæ or Rust Fungi—
Black rust of wheat . . . 414
Yellow rust of wheat . . 415
Other rusts 415
The Ustilagneæ—
Smut of oats 416
Wheat smut 416
Naked barley smut and covered barley smut 416
Bunt of wheat 416
Hyphomycetaceæ—
Early blight or potato leaf curl 417
Potato scab 417
The Slime Fungi or Myxomycetes 417
Finger-and-toe or club-root . 417
Bacteria 418
Black-rot of cabbages . . . 418

DODDER—A PARASITIC FLOWERING-PLANT.

Clover-dodder 423
Lesser dodder 423
Greater dodder 423
Flax dodder 423
Life-history 423
Treatment 424

THE SMALLER MAMMALS IN RELATION TO FARM LIFE.

Carnivora—
Fox 424
Wild cat 425
Other small carnivores . . 425
Stoats 425
Weasel 425
Polecat 425
Badger 425
Otter 426
Rodents—
Rats, mice, and voles . . . 426
The black rat 426
The brown rat 426
Mice—
The common house-mouse . 427
The long-tailed field-mouse or wood-mouse 427
The harvest-mouse . . . 428
Voles—
The water-rat or water-vole . 428
The short-tailed field-vole . 428
The bank-vole 428
Measures against mice and voles. 429
Hares and rabbits 429
The squirrel 429
Insectivora—
The hedgehog 429
The mole 429
The shrew—
The shrew-mice . . . 430
The common shrew . . . 430
The water shrew . . . 431
The lesser shrew . . . 431

BIRDS IN RELATION TO THE FARM.

Birds of prey—
The kestrel 431
The sparrow-hawk . . . 431
The barn owl 431
The brown or tawny owl . . 432
The long-eared owl and the short-eared owl 432
The crow family—
Raven 432
Rook 432
Jackdaw 434
Chough 434
Magpie 434
Jay 434
Pigeons—
Wood-pigeon, or cushat, or ring-dove 434
Stock-dove 436
The starling 436
Thrush family—
Song-thrush, or mavis, or throstle 436
Missel-thrush 436
Blackbird 436
Swallows and martins . . . 437
The spotted fly-catcher . . . 437
The water-wagtails 437
The titmice 437
The great tit or tom-tit . . 437
Buntings—
Yellowhammer 438
Reed-bunting 438
Corn-bunting 438
The finches—
The chaffinch or shilfa . . 438
The greenfinch or green linnet . 439
Linnet 439
Goldfinch 439
Bullfinch 439
Protective measures against disbudding 439
The sparrow—
The house-sparrow . . . 439
Tree-sparrow 440
The larks 440
The plovers—
The lapwing, peewit, or green plover 440
The cuckoo 440
Gulls 441
The black-headed gull . . . 441
The common gull . . . 441
Herring gull 441

Game birds—
The pheasant 441
Partridge 441

INSECTS INJURIOUS TO FARM CROPS.

Nervous system 442
Respiration 442
Reproduction 442
Classification of insects 443
Orders containing insects of importance in agriculture . . 443
Crop pests—
Bean aphis or collier 444
General treatment for aphides or plant lice 444
How to make paraffin emulsion 444
Bean and pea beetles—
Bean beetle 445
Bean weevils 459
Beet carrion beetle 445
The carrot fly 445
Wireworms 453
Beet and mangold—
The pigmy mangold beetle . 446
Mangold-leaf maggot . . 446
Cabbage butterflies 446
The cabbage moth 447
Cabbage root fly 447
Cabbage root gall weevil . . 463
The cabbage flea beetle . . 448
Cabbage aphis 449
The celery fly 449
The cereals—
Daddy-long-legs or crane-flies . 449
Gout-fly or the ribbon-footed corn-fly 450
Frit-fly 451
Wheat bulb-fly 451
Hessian fly 452
The wheat midge 452
The corn sawfly 453
Wireworms 453
Click beetles 454
The cockchafer 455
The garden chafer or bracken clock 455
Corn ground-beetle 455
Corn and rice weevil 455
Flour beetles 456
Corn thrips 456
The order Thripidæ 456
Hops—
Hop aphis 456
Winter washing of fruit-trees . 457
Natural enemies of the hop aphis 457
The hop frog-fly 457
Fever-fly 458
The hop-flea or brassy-flea beetle 458
Hop red-spider 458
The onion-fly 459
Parsnip-fly 449
Peas—
The pea beetle 445
Pea and bean weevils 459
Pea moth 460
Pea midge 460
Pea thrips 461
Potatoes—
The Colorado beetle 461
The death's-head moth . . . 462
Turnips—
The turnip mud-beetle . . . 462
The turnip and cabbage gall-weevil 463
The flea-beetles 463
Turnip-fly or flea-beetle . . 463
The diamond-back moth . . 464
Surface caterpillars 465
Heart-and-dart moth . . 465
Turnip moth 465
The turnip sawfly 466
Spring-tails or Collembola . . 466
Fruit—
Raspberries—
Raspberry weevils 467
Raspberry beetle 467
Raspberry moth 467
Strawberries—
The black vine weevil . . 467
Ground-beetles 467
Gooseberries and currants—
The magpie moth . . 468
Sawfly 468
The black currant gall mite . 468
Aphides 468
Useful insects—
Useful beetles 469
Carabidæ or ground-beetles . . 469
Rove beetles 469
Ladybirds 469
Useful flies 469
Useful Hymenoptera 469
The Neuroptera or nerve-winged insects 470
Centipedes and millepedes . . 470
Eelworms 470
Ear-cockle of wheat 470
Tulip root of oat or segging . 471
Tomato root-rot 471
Literature of entomology . . 471

SNAILS AND SLUGS.

Snails—
The garden snail 472
The wood snail 472
Helix hortensis, Müll 472
The strawberry snail 472
The hairy snail 473
The small banded snail . . 473
The allied banded snail . . 473
Slugs—
The large black slug 473
The garden slug or small arion . 473
The black striped or mottled slug 473

The grey field slug . . . 473
The household or cellar slug . 473
The root- or bulb-eating slug . 474
Preventive and remedial measures . 474
Slugs that devour worms and insect larvæ 474
Literature 474

DAIRY WORK.

The dairy 475
Situation of the dairy . . . 475
A medley in the milk-room . . 476
Separate dairy 476
Compartments in the dairy . . 476
Verandah 476
Finishings of the dairy . . 476
Dampness to be avoided . . 476
Milk shelves 476
Temperature of the dairy . . 477
Importance of temperature . . 477
Thermometers 477
Dairy utensils 477
Power for the dairy 477

Milk.

Composition 478
Butter-fat 478
Yield of butter 478
Composition of milk from different breeds 478
Testing percentage of cream 479
Fat-globules 479
Casein 479
Milk-sugar 480
Albumen 480
Weight and specific gravity . 480
Milk statistics 480
Milk records 480
Appliances for weighing milk . 480
Purifying and preserving milk . 481
Pasteurisation of milk . . . 481
The turbine-driven pasteuriser 481
Belt-driven pasteurisers . . 482
Motor-driven pasteuriser . . 482
Sterilisation of milk . . . 482
Sterilised milk in bottles . 482
Homogenised milk . . . 483
Cooling of milk 483
Milk coolers 483
Tubular coolers . . . 483
Cold store 483
Refrigerating machine . . 484
Condensed milk . . . 484
Destination of the milk . . . 484
Consumption and selling of whole-milk 485
Milk-selling trade . . . 485
Co-operative milk depots . . 485
Methods of milk distribution . 485
Milk bottles 485
Railway milk churn or can . 485
Cleaning dairy utensils . . 486
Milk for calves 486
Cream-raising 486
Principles of cream-raising . . 486
Methods of raising cream . . 487
Shallow-pan system . . . 487
Airing cream 487
Disadvantages 487
Temperature and shallow pans 487
Shallow pans 487
Zinc unsuitable for utensils . 488
Milk-sieve 488
Skimmer 489
Cream-jar 489
Shelves 489
Deep setting 489
The Swartz system . . . 489
The Cooley system . . . 489
Swartz and Cooley systems compared 490
Atmospheric influence on cream 490
Ice used in summer . . . 490
Advantages of deep setting . 490
Disadvantages of deep setting . 490
Devonshire scalding system . . 490
Method of working . . . 490
Merits of the scalding system . 490
Other methods of raising cream . 491
Centrifugal separator . . 491
Working of the separator . . 491
Advantages of the separator . 492
Selling cream and skim-milk—
Separated cream 492
Preserving cream 492
Devonshire clotted cream . 492
Separated milk 492

Butter-making.

Ripening cream 493
The use of a "starter" or pure culture 493
Starter jelly 493
Uniform ripening of cream . . 494
Influence of salt in ripening . . 494
Sweet-cream butter 494
Times of churning 494
Temperature of cream for churning 494
Effect of food on the churning temperature of cream . . . 495
Churning whole-milk—
Advantages of 495
Disadvantages of 495
Methods of preparation . . 495
Continental method . . . 496
Churns 496
Types of churns 496
Plunge churn 496
Barrel churns—
End-over-end churn . . . 496
Diaphragm churn . . . 497
Other forms—
Holstein churn 497

Streamlet churn 497
"Speedwell" crystal churn . . 497
Swing churn 497
High-speed churns 497
Factory churns 497
Combined churn and butter-worker 498
Important features in a churn . 498
Churning—
Preparing the churn 498
Straining cream 498
Speed of the churn 499
Ventilation 499
Breaking water 499
Time churning 499
Sleepy cream 499
Butter-working—
Object of working 499
Hand-working objectionable . 499
The butter-worker 500
Salting butter 500
Centrifugal butter-drier . . 500
Scotch hands 501
Packing into crocks 501
Fresh butter 501
Butter boxes for transit . . 501
Colouring butter 501

Cheese-making.

Cheese-making 501
Apartments for cheese-making . 502
Utensils 502
The vat 502
Curd-mill 502
Presses 503
Rennet 503
Action of rennet 503
Acidity 504
Ripening 504
"Starters" 504
Culture-starters 505
Propagation of a "culture-starter" . 505
Controlling the acidity . . . 505
Measuring the acidity . . . 506
Cheddar cheese 506
Character and composition . . 506
Scale of points 507
Character of milk 507
Treatment of the milk . . . 507
Testing acidity 507
Colouring 508
Renneting 508
Cutting the curd 508
Cooking 508
Testing acidity of curd . . 509
Draining 509
Milling 509
Salting 509
Pressing 509
Curing 510
Skim-milk cheese 510
Stilton cheese 510
Characteristics of 510
Climate and soil 511
Method of making 511
Cheshire cheese 511
Leicestershire and Derbyshire cheese 512
Lancashire cheese 513
Yorkshire cheese 513
Other West of England cheese . 513
English soft cheeses 513
Bath cheese 514
Caerphilly cheese 514
Method of manufacture . . 514
Foreign cheeses suitable for Britain 515
Gruyère 516
Dutch cheeses—
Edam 516
Gouda 517
Parmesan 517
Gorgonzola 518
Analyses of 519
Roquefort 519
Cantal 519
Camembert 520
Bacteria 520
Brie 520
The Neufchatel 521
Pont l'Evêque 521
Associated butter and cheese making 522
Creameries 522
Butter-blending house . . . 522
Dairy factory 522
Co-operative milk depot . . 522

General Index to Volume II. 523

LIST OF ILLUSTRATIONS IN VOLUME II.

FIG.		PAGE
347.	White campion (seed)	74
348.	Chickweed (seed)	74
349.	Perennial red clover (seed)	74
350.	Cut-leaved geranium (seed)	75
351.	Alsike clover (seed)	75
352.	Dove's-foot geranium (seed)	75
353.	Pansy (seed)	75
354.	White clover (seed)	75
355	Suckling clover (seed)	76
356.	Lucerne or alfalfa (seed)	76
357.	Trefoil or yellow clover (seed)	76
358.	Kidney vetch (seed)	77
359.	Rib-grass (seed)	77
360.	Way-bread (seed)	77
361.	Upright crowfoot (seed)	77
362.	Creeping crowfoot (seed)	77
363.	Buckwheat (seed)	78
364.	Sheep's sorrel (seed)	78
365.	Red-shank (seed)	78
366.	Yarrow, or milfoil (seed)	79
367.	Ox-eye daisy (seed)	79
368.	Field chamomile (seed)	79
369.	Knapweed (seed)	79
370.	Field thistle (seed)	79
371.	Chicory (seed)	80
372.	Dandelion (seed)	80
373.	Nipplewort (seed)	80
374.	Parsley (seed)	80
375.	Field madder (seed)	81
376.	Self-heal (seed)	81
377.	Scorpion-grass (seed)	82
378.	Meadow foxtail grass (seed)	83
379.	Black grass (seed)	83
380.	Yorkshire fog (seed)	83
381.	Tall oat-grass (seed)	84
382.	Catstail or timothy (seed)	84
383.	Indian rye-grass (seed)	85
384.	Perennial rye-grass (seed)	85
385.	Meadow fescue-grass (seed)	85
386.	Tall fescue-grass (seed)	85
387.	Fine-leaved fescue (seed)	86
388.	Hard fescue-grass (seed)	86
389.	Crested dogstail-grass (seed)	86
390.	Squirrel-tail fescue-grass (seed)	87
391.	Soft brome-grass (seed)	87
392.	Rye seeded brome-grass (seed)	87
393.	Cocksfoot-grass (seed)	87
394.	Smooth-stalked meadow grass (seed)	87
395.	Rough-stalked meadow grass (seed)	87
396.	Golden oat-grass (seed)	88
397.	Wavy mountain hair-grass (seed)	88
398.	Tufted hair-grass (seed)	88
399.	Clover-dodder (seed)	89
400.	Classification of wheat by the ear	92
401.	Short, round, plump form, and small size of wheat	92
402.	Long medium-sized form of wheat	92
403.	Large size and long form of wheat	93
404.	(*a*) 4-rowed bere or bigg; (*b*) 6-rowed barley; (*c*) 2-rowed barley	96
405.	Scotch bere or bigg	96
406.	English barley	96
407.	Potato oat	98
408.	White Siberian early oat	98
409.	Spike of potato oat	98
410.	Spike of Tartarian oat	99
411.	Ear of rye	101
412.	Grains of rye	101
413, 414.	Organs of fructification in wheat	105, 106
415.	(*A*) To illustrate the results of crossing two wheats differing in two pairs of characters; and (*B*) the results of crossing two barleys differing in two pairs of characters	111
416.	Double-furrow plough	120
417.	Sowing-sheet and hand-sowing corn	122
418.	English sowing-basket	122
419.	Broadcast sower ready for work	123
420.	Broadcast sower in transit	123
421.	Corn and seed drill	124
422.	Horse-hoe	124
423.	Hand seed-drill	124
424.	Broadcast hand-sower	125
425.	English iron harrows	125
426.	Scottish iron harrows	125
427.	Weed-hook	129
428.	Apparatus for pickling wheat	130
429.	Cast-iron land-roller	142
430.	Water-ballast roller	143
431.	Field feered for cross-ploughing	145
432.	Horse-beans	147
433.	Partridge field-pea	148
434.	Saddle drill-harrow	152
435.	Cloddy and stony soil	155
436.	Soil with water and without air	155
437.	Soil with air and without water	156
438.	Soil with water and with air	156
439.	Component parts of a grain of wheat	157

440. Wheat plant in the state of germination 157
441. Well-ploughed regular furrow-slices 158
442. Positions of seeds on regular furrows 158
443. Irregular braird upon regular furrows 158
444. Ill-ploughed irregular furrow-slices 158
445. Irregular positions of seed on ill-ploughed furrows . . . 158
446. Irregular braird on ill-ploughed furrow 158
447. Regular depth of seed by drill-sowing 159
448. Regular braird from drill-sown seed 159
449. Newberry's one-rowed dibbling-machine 163
450. Newington's six-rowed dibbling-machine 164
451. Double roots of deep-sown wheat . 165
452. Roots of shallow-sown wheat . . 165
453. Hook or sickle 170
454. Large smooth-edged sickle . . 170
455. Sheaf-gauge 170
456. Reaping with the Hainault scythe . 171
457. Cradle-scythe for reaping . . 171
458. Common reaping-scythe . . 171
459. Bell's reaping-machine 173
460. Dray's Hussey reaping-machine in perspective 174
461. Harrison, M'Gregor, & Co.'s self-delivery reaper 176
462. Howard's self-delivery reaper . 176
463. Finger arrangement 177
464. Conveyor-roll 178
465. Knotter 178
466. Half turn 179
467. Whole turn, jaws open and string entering 179
468. Jaws closed on string; the string-knife then cuts the ends, and the lever draws the string off, completing the knot 179
469. Knot tied by the Hornsby binder . 179
470. Bevel gear and vibrating buttor . 179
471. Wood's New Century reaper and binder 180
472. Bisset's binder 180
473. Reaper knife-sharpener 183
474. Corn-band ready to receive the sheaf 184
475. Hand stubble-rake 185
476. Barley or oat stook hooded . . 187
477. Gaitin of oats 187
478. Corn and hay cart tops or frame . 190
479. Transverse section of the tops or frame 190
480. Common corn and hay cart . . 191
481. Coiled-up cart-rope 192
482. Making a stool for a corn-stack . 193
483. Building a stack of corn . . 194
484. Stack-trimmer 194
485. Old throw-crook 195
486. Best throw-crook 195
487. Making a straw-rope with a throw-crook 196
488. Coil of straw-rope 196
489. Bunch of drawn straw 197
490. Thatch-making machine . . . 197
491. Lozenge mode of roping the covering of a corn-stack 198
492. Net-mesh mode of roping the covering of a corn-stack 199
493. Border mode of roping the covering of a corn-stack 199
494. Pyramidal boss and trestle . . 201
495. Prismatic boss 201
496. Taylor's stack ventilator . . 202
497. Richmond drying-rack—empty . 203
498. Richmond drying-rack—full of grain 203
499. Richmond drying-rack—section . 204
500. Cross-beam fixing strainers . . 204
501. Platform for filling 206
502. Hanging-rod for platform . . 206
503. Bracket for platform 206
504. Combined grain-drying rack and shed 208
505. Modern Scottish threshing and dressing machine 211
506. Portable threshing-machine at work 213
507. Section of portable threshing-machine 214
508. Straw and hay elevator . . . 215
509. Portable threshing-machine . . 215
510. Straw-trusser 216
511. Small threshing-machine . . 216
512. Section and elevation of a bucket water-wheel 219
513. Ladder for farm steading . . 222
514. Oil-can 223
515. Combined winnower and bagging-machine 224
516. Old wooden wheat-riddle . . 225
517. Old wooden barley-riddle . . 225
518. Old wooden oat-riddle . . . 225
519. Old wooden bean-riddle . . . 226
520. Old wooden riddle for the roughs of wheat and corn 226
521. Wooden sieve 226
522. Iron-wire sieve 226
523. Triangular-meshed iron-wire sieve . 226
524. Wecht of skin 227
525. Corn-basket of wicker-work . . 227
526. Barn wooden hoe 227
527. Wooden corn-scoop 227
528. Imperial bushel of a convenient form 227
529. Corn-strikes: (*a*) flat, (*b*) cylindrical 227
530. Simple hand-hummeller . . . 228
531. Sack-lifter 229
532. Combined sack-barrow and lifter . 229
533. Sack-barrow 229
534. Portable weighing-machine . . 230
535. Fiorin, or creeping bent grass 231
536. Meadow foxtail 231
537. Sweet-scented vernal 232
538. Yellow oat-grass 232
539. Crested dogstail 233
540. Rough cocksfoot 234
541. Meadow fescue 234
542. Tall fescue 235
543. Sheep's fescue 236
544. Hard fescue 236
545. Perennial rye-grass 237
546. Italian rye-grass 238
547. Timothy 239

548. Smooth-stalked meadow-grass . 240
549. Rough-stalked meadow-grass . . 240
550. Evergreen meadow-grsss . . 241
551. Perennial red clover . . . 242
552. Red or broad clover . . . 242
553. Perennial white clover . . . 243
554. Alsike clover 243
555. Common yellow clover or trefoil . 244
556. Grass-seed iron harrows, with wings and swing-trees 249
557. Chain harrows 245
558. Carriage for conveying harrows, &c. 249
559. Howard's mower 256
560. The "Albion" mower . . . 257
561. Jack's reaper and mower . . 257
562. Howard's haymaker . . . 259
563. Swathe-turner 259
564. Horse-rake 260
565. Haud hay-fork 262
566. Hay-collector 265
567. Wallace's hay-sledge, empty . . 266
568. Wallace's hay-sledge, in the act of loading 266
569. Wallace's hay-sledge, with load . 266
570. Hay-shed 270
571. Hay hand-rake 272
572. Wallace's hay clip-fork (open) . 274
573. Wallace's hay clip-fork (closed) . 275
574. Mode of erecting a rick-cloth over a hay-stack when being built . 277
575. Hand-flail 278
576. Hay and straw hand-power press . 279
577. Morgan's hay- and straw-press . 279
578. Johnson's ensilage press . . 292
579. Blunt's ensilage press . . . 292
580. Scottish drill-plough . . . 302
581. Potato-planter 305
582. Potato hand-basket . . . 306
583. Triple drill-plough . . . 306
584. Drill roller 307
585. Section of a flower (potato) . . 311
586. Horizontal section 311
587. Vertical section of a potato blossom 312
588. Stamen discharging pollen . . 312
589. Pistil with pollen-grains on top . 312
590. Pollen-grain magnified . . . 312
591. Vertical section of style and stigma magnified 312
592. Potato-plum 313
593. Plum cut, showing seeds inside . 313
594. Potato-seed magnified . . . 313
595. Potato-graip 315
596. Potato-digger 317
597. Jack's farm-cart 318
598. Potato-raiser attached to a plough . 321
599. Conical and prismatic potato-pits . 322
600. Varieties of turnips—white globe, purple-top swede, green-top yellow 325
601. Ill-shaped turnip, tankard turnip . 327
602. The Tennant grubber . . . 330
603. Clay's grubber 330
604. Martin's cultivator . . . 331
605. Turnip drill-sower 337
606. Farm tip-cart 349
607. Tip-cart going down-hill . . 349
608. Drill cultivator 352
609. Drill horse-hoe 352
610. Disc drill scarifier 353
611. Improved hand-hoe . . . 353
612. Turnip hand-hoe 353
613. Triangular turnip-store . . . 357
614, 615. Implements for topping and tailing turnips 359
616. Turnip-trimming-knife . . . 359
617. Mode of topping and tailing turnips 359
618. Crosskill's clod-crusher . . . 386
619. Side view of one wheel of the clod-crusher 386
620. Norwegian harrow 386
621. Section through fragment of potato-leaf, showing the potato fungus . 407
622. The Strawsoniser at work . . 409
623. Warty disease of potatoes; different stages of infestation . . . 410
624. Warty disease in potatoes . . 410
625. 1, Gooseberry mildew; 2 and 3, American gooseberry mildew . 413
626, 627. Rust in wheat . . 420, 421
628. Finger-and-toe in turnips . . 422
629. Turnip white-rot 418
630. The field-vole 428
631. Mole-heap 430
632. Bean aphis 444
633. The bean beetle 445
634. Beet-fly 446
635. Large white cabbage butterfly . 447
636. Small white cabbage butterfly . 447
637. The cabbage root fly . . . 448
638. The celery fly 449
639. Daddy-long-legs 449
640. Ribbon-footed corn-fly . . . 450
641. The frit fly 451
642. Hessian fly 452
643. Wheat midge 453
644. Corn sawfly 453
645. Wireworm on carrot . . . 454
646. Wireworms; grubs of click beetles 454
647. Corn weevil 455
648. Hop aphis; green fly . . . 457
649. Hop frog-fly 458
650. Red-spider 458
651. Onion-fly 459
652. Pea and bean weevils . . . 460
653. Colorado beetle 461
654. Death's-head moth . . . 462
655. The turnip mud-beetle . . . 462
656. Turnip-fly 463
657. Diamond-back moth . . . 464
658. Turnip moth 465
659. Turnip sawfly grub at work . . 466
660. Turnip sawfly 466
661. False wireworms 470
662. Ear cockles; wheat cockle-gall; eel-worm 470
663. Tulip-rooted oat plant infested by eelworm 471
664. Sandringham dairy herd recorder . 480
665. Pasteuriser tin can . . . 481
666. Turbine-driven pasteuriser . . 481
667. Bottle for sterilised milk . . 482
668. Lawrence flat cooler . . . 483
669. Laval cylindrical cooler . . 483
670. Hall's refrigerating machine . . 484
671. Enoch's refrigerator . . . 484
672. Milk bottle and wooden disc . . 486
673. Railway milk churn . . . 486
674. Steaming block . . . 486

675. White porcelain milk dish . . 488
676. Iron milk-pan 488
677. Milk-sieve 488
678. Milk filter 488
679. Creamery strainer 489
680. Cream skimmer 489
681. Swartz system 489
682. Cooley system 489
683. Devonshire cream stove . . . 490
684. Hand separator 491
685. Belt-driven separator . . . 492
686. End-over-end churn . . . 496
687. Diaphragm churn 497
688. Speedwell crystal churn . . 497
689. Factory churn 498
690. Combined churn and butter-worker 498
691. Scotch hand 500
692. Butter-worker 500
693. Milk-vat 502
694. Curd-mill 503
695. Single cheese-press . . . 503
696. Double cheese-press . . . 503
697. Curd-knives 508
698. Curd-breaker 508
699. Wooden chesset or cheese-mould . 510
700. Metal chesset or cheese-mould . 510

THE

BOOK OF THE FARM.

EXPERIMENTS IN MANURING CROPS.

ROTHAMSTED EXPERIMENTS.

ROTHAMSTED has become a household word wherever science is applied to agriculture. In 1834 Sir (then Mr) John Bennet Lawes succeeded to the estate of Rothamsted, Hertfordshire, and soon after began to conduct experiments with different manuring substances, first with plants in pots, and afterwards in the field. In 1840 and 1841 somewhat extensive field trials were carried out, and in 1843 the experiments were begun upon the comprehensive and systematic form which they have ever since maintained. The foundation of the Rothamsted Experimental Station is therefore usually dated from 1843.

The experiments, the most elaborate and comprehensive of the kind ever attempted in any country, have from the first been maintained entirely by the late Sir John Bennet Lawes, Bart., LL.D., who gave in trust the handsome sum of £100,000, besides certain areas of land, to ensure to British agriculture the benefits and guidance derivable from the perpetual continuation of the Rothamsted experiments.

The Committee to whom the management of the Experimental Station is entrusted consists of representatives of the Royal Society, the Royal Agricultural Society of England, the Chemical and Linnean Societies, and the owner of Rothamsted.

From 1843 until the death of Sir John Lawes in 1900, Sir J. H. Gilbert was associated with the conduct of the experiments, and had the direction of the laboratory: the familiar names "Lawes and Gilbert" appear on the titles of about 60 papers published between 1851 and 1900. Lawes died in 1900, and Gilbert followed him a little more than a year later, in 1901.

During the lifetime of the founders of the Rothamsted experiments one or more trained chemists, besides the assistants engaged in routine work, were on the staff of the station: for many years also the late R. Warington, F.R.S., was at work in the Rothamsted laboratory, and there conducted his long series of investigations into nitrification and the nature and composition of drainage-waters with which his name is chiefly associated.

Since the death of Sir Henry Gilbert, Mr A. D. Hall has been Director of the Experimental Station, which, by the generosity of the Goldsmiths' Company and other individuals, has been enabled to enlarge its staff and bring its equipment more into line with that of a modern agricultural research station.

Main Features of the Work.—The special feature of the Rothamsted Ex-

perimental Station has always been the manurial experiments upon the principal farm crops, wheat, barley, roots, clover, hay; field experiments which have been carried out without variation for more than fifty years, so that all fluctuations due to season or to inequalities of the soil have been swept away from the results, and the effect of the manure upon the yield, the quality of the crop, and again upon the soil, has become manifest in a fashion unrivalled in any other series of experiments. At the same time, investigations into soils and such collateral questions as rain and drainage-waters have always been pursued, while for many years feeding experiments upon cattle, sheep, and pigs were conducted, and led to the enunciation of some of the fundamental laws of animal nutrition.

The Soil.—The Rothamsted Estate adjoins the village of Harpenden. The land lies mostly about 400 feet above the sea. The average rainfall is about 28 inches. The surface-soil is a heavy loam, containing many flint stones; the subsoil is a pretty stiff clay, resting on chalk. The chalk is usually about 9 feet from the surface, and affords a good natural drainage. The land does not bear a high rent. The soil is a fair one for wheat, but would not be considered as specially suited for barley; it is still less suited for turnips. The land in the district is still largely under the plough, though much of it has been laid down to grass and affords fair summer grazing for bullocks and dairy-cattle, but is rather too heavy for sheep.

Scope of the Manurial Experiments.—Different fields on the farm have been set apart for the study of individual crops: thus one has been devoted to wheat, one to barley, one to roots, &c. In each of these fields the crop has, as a rule, been grown continuously for many years without the intervention of fallow or any other crop.

In the early years of the experiments trials were made with various miscellaneous manures, and the same plot of land did not each year receive the same manure, but since 1851 the present systematic treatment has been adopted, and the same manure applied to the same plot every year. In nearly every case farmyard manure has been annually applied to one portion of the experimental field, while another portion has been left entirely without manure. The other plots have received the various chemical constituents of manure, either singly or in mixture with each other. The substances applied have been generally—ammonium-salts, nitrate of soda, rape-cake, superphosphate of lime, sulphate of potash, sulphate of magnesia, and sulphate of soda. The object has been to supply the various constituents of plant-food (see p. 326, vol. i., Div. ii.) in their most soluble and active form, and thus obtain their greatest effect. By employing substances of known composition, it is also possible to calculate how much of each constituent has been applied to the land.

Each plot of land has, during the later systematic portion of the experiments, received each year, as a rule, the same manure. By this plan trustworthy averages of the amount of produce yielded under each condition of manuring are obtained, and also ample information as to the influence upon the produce of seasons of different character. The permanent or temporary effect of the manures is also shown.

By long-continued treatment of this kind the soil of the experimental field, which was at first practically the same throughout, has been altered, so that the different plots now represent extremely different conditions of food-supply. On certain plots the crop now grows in soil specially exhausted of nitrogen, or phosphates, or alkalies, to an extent which can very rarely occur in farm practice; while in the soil of other plots abundance of these constituents has accumulated.

The work has not been confined to a determination of the amount of produce obtained from each manure,—the crops have themselves been analysed at the Rothamsted laboratory. Information has thus been obtained as to the proportion of the manure that is recovered in the increase of the crop, and also respecting the alteration in the composition of the crop brought about by the differences in the composition of the soil and the character of the season. The effect of the manures upon the yield of the various crops may indeed be considered as settled by the fifty years of results

that have accumulated: much, however, yet remains to be investigated as to their effect upon the quality of the crops and upon the soil.

Soil and Drainage-water Investigations.—The investigation has further extended to the soil. After applying the same manure to the same land for many years, it becomes possible to learn by soil analysis what accumulation or exhaustion has taken place, and the depth to which manure has penetrated. In one of the fields the drainage-waters are collected and examined: the nature and amount of the soluble matters lost by drainage, under various conditions of manuring, are thus indicated. The investigations relating to the soil are, from the difficulty of the subject, in a less advanced stage than those relating to the effect of manures on crops.

Scientific Character of the Trials.—It will be seen from the above sketch that the object of the investigations has been primarily scientific. It has not been the aim to demonstrate directly the most economical manuring for each crop. None of the experiments have been designed with a view to a money profit: on very few of them would there be any profit if conducted on a large scale. The whole investigation, therefore, might stand condemned by the so-called "practical" man as a mere scientific amusement, from which he has nothing to learn. He, indeed, may learn little, but if so it will be because he lacks the elementary knowledge which is necessary for an appreciation of the results.

The mode of investigation adopted is, however, one which must add largely to our true knowledge of crops, manures, and soil. This knowledge will be turned to practical account in a number of ways by a skilful farmer; but to provide him with practical rules has not been the immediate object of the investigation. To have aimed directly at practical results would have cramped the whole inquiry, and defeated its highest purpose.

EXPERIMENTS ON THE CONTINUOUS GROWTH OF WHEAT.

The experiments on wheat are among the oldest of those at Rothamsted. Broadbalk field has been under arable culture for at least two or three centuries. It grew its last turnip crop in 1839: this was followed by barley, peas, wheat, and oats. The last four crops were without manure.

The continuous growth of wheat commenced in 1843, and has since proceeded without interruption, so that the present crop (1907) is the 64th crop of wheat in succession upon this field. The cultivation of the land has been that usual in the district: there has been no deep ploughing. During the course of the experiments the variety of wheat sown has been changed three or four times; latterly Square Head's Master has been sown, a fresh stock of seed being procured each year. The area of the plots is in nearly all cases one half acre. Formerly the artificial manures were sown broadcast, screens being carried on each side of the sowers to prevent the manure falling on other plots; latterly a machine has been used. The wheat is drilled in October, 2 bushels of seed being used. In the spring and early summer great care is taken to remove weeds, the most troublesome of which is the grass *Alopecurus agrestis*. The luxuriance of weeds, in the absence of fallow crops, will always prove a practical objection to the continuous growth of corn, and especially of winter corn.

Without Manure.

In Table I. (p. 4) is shown the average produce per acre on Plot 3, without manure, in the first eight years, and five succeeding periods of ten years.

If all the seasons had been perfectly alike, the produce of the unmanured land would doubtless have fallen throughout the experiment—rapidly at first, but very slowly after the first ten years. The very variable character of the seasons in our climate prevents any such regularity in the produce. Indeed, putting aside the fluctuations due to season, the crop during the last forty years would almost seem to have reached a stationary condition, a certain proportion of the original capital of plant-food in the soil becoming available each year. It is noteworthy that under such extreme conditions of soil-exhaustion as prevail on this plot the quality of the grain does not suffer: in 1906 it weighed 63 lb. per bushel, and

when converted into flour made as good loaves as the grain from any other plot.

The average produce of fifty-eight years of continuous wheat-growing without manure is seen to be 13.7 bushels. It is interesting to note that this amount is quite equal to the average yield of the principal wheat-producing countries of the world. Thus, the average yield of the United States is 13 bushels, of Russia 10 bushels, and of India 11 bushels.

TABLE I.—PRODUCE OF WHEAT WITHOUT MANURE, FIFTY-EIGHT YEARS (1844-1901).

	Dressed Corn.		Straw.
	Quantity.	Weight per Bushel.	
	bush.	lb.	cwt.
Eight years, 1844-51 . .	17.2	60.0	15.5
Ten years, 1852-61 . .	15.9	55.8	15.2
,, 1862-71 . .	14.5	59.4	11.5
,, 1872-81 . .	10.4	57.9	8.5
,, 1882-91 . .	12.6	59.8	8.5
,, 1892-1901 . .	12.3	61.3	9.1
Mean of fifty-eight years .	13.7	59.0	11.2

With Farmyard Manure.

Ordinary yard manure, at the rate of 14 tons per acre, has been annually ploughed in in October on Plot 2; the produce is shown in Table II.

TABLE II.—PRODUCE OF WHEAT WITH FARMYARD MANURE, FIFTY-EIGHT YEARS (1844-1901).

	Dressed Corn.		Straw.
	Quantity.	Weight per Bushel.	
	busb.	lb.	cwt.
Eight years, 1844-51 . .	28.0	61.1	26.6
Ten years, 1852-61 . .	34.2	58.8	33.9
,, 1862-71 . .	37.5	61.3	34.0
,, 1872-81 . .	28.7	59.8	28.0
,, 1882-91 . .	38.2	61.0	34.8
,, 1892-1901 . .	39.2	62.3	38.7
Mean of fifty-eight years	34.5	60.7	32.9

Plant-food in Dung.—The amount of plant-food supplied is much larger than on any other plot in the field. The fourteen tons of farmyard manure are estimated to contain 200 lb. nitrogen, 235 lb. potash, 35 lb. magnesia, 31 lb. lime, and 78 lb. phosphoric acid, with a number of other substances, including a large amount of silica, which is at present supplied to no other plot in the field. In consequence of this large supply there has been a great accumulation of manurial matter in the soil, which is now far richer than that of any other plot in the field.

Limits to High Manuring.—The table shows a considerable rise in the produce during the earlier years of the experiment, owing to the accumulation of food in the soil. This rise afterwards ceases. Everything, indeed, in nature tends to come to an equilibrium. On

the unmanured land the crop falls, till its demands equal the annual supply from soil and atmosphere. On the dunged plot the produce rises, till here, too, the crop equals the annual supply of assimilable food. With very high manuring we meet with another limit, that of season. A larger crop cannot be produced by manure than the character of the season will admit of.

The average produce with farmyard manure in fifty-eight years has been 34½ bushels: the highest produce was 48½ bushels in 1891.

Nitrogen in Dung.—Notwithstanding the richness of the soil, the farmyard manure plot very seldom yields the highest produce in the field, both nitrate of soda and ammonium-salts proving more effective. The nitrogen in farmyard manure is in fact principally combined with carbon, and exists as nitrogenous humic matter; only a limited portion of this is each season oxidised to nitrates, and thus becomes available to the crop.

Mechanical Influence of Dung.—Not a few of the advantages attending the use of farmyard manure are due to its improvement of the physical condition of the soil. In the present case the soil, while becoming less heavy, has also become more retentive of moisture, and the crop thus suffers less in time of drought (*Jour. Royal Agric. Soc.*, 1871, p. 91). The produce of this plot is more even, and less affected for good or evil by the vicissitudes of season, than on the other highly manured plots in the field.

With Ash Constituents.

When water has been removed, the constituents of a plant may be classed under two heads—the combustible and the incombustible.

The *incombustible* portion is very small: in wheat grain it is about 1.7 per cent, in wheat straw about 4.6 per cent. It consists of the phosphates, potash, lime, magnesia, silica, &c., derived from the soil.

The *combustible* part is made up of the carbon, oxygen, and hydrogen derived from the atmosphere and rain, and of the nitrogen derived from the soil. The quantity of the principal ash constituents, and of nitrogen, contained in a wheat crop of 30 bushels, has been already given on p. 326, vol. i., Div. ii.

Of the substances present in the ash, six—potash, lime, magnesia, iron, phosphoric and sulphuric acid—are quite indispensable for plant-growth.

Mineral Theory.—At the time when the Rothamsted experiments commenced, chemists had a very exaggerated notion of the amount of ammonia annually supplied by rain. Liebig, owing to this mistaken idea, taught in 1843 that the ashes of a manure contained its true active ingredients; that where the necessary ash constituents of a crop were supplied by manure, the crop would have no difficulty in obtaining all the nitrogen it required from the atmosphere. This view was known as the "mineral theory." The state of opinion at the time must be borne in mind in considering the Rothamsted field experiments, as they were planned to a considerable extent to test the truth of the mineral theory.

In the first season of the wheat experiments (1843-1844), one plot received 14 tons of farmyard manure, and a second plot the ashes from another lot of 14 tons, with the following result:—

	Dressed Corn.	Total Corn.	Total Produce.
	bush.	lb.	lb.
Farmyard manure, 14 tons .	20½	1276	2752
Ashes of ditto . .	14½	888	1992
Unmanured . .	15	923	2043

The plot receiving the ashes thus yielded no more produce than the plot entirely without manure.

Various systematic experiments have since been made with the ash constituents of wheat: these have been supplied in abundance, and the crop left to obtain its carbon and nitrogen from

the natural resources of the soil and air.

Plot 5 has received superphosphate of lime and a mixture of the sulphates of potash, soda, and magnesia—generally termed by Lawes and Gilbert the "mixed mineral" manure, and representing the ash constituents of the crop without nitrogen. It consists of 3½ cwt. superphosphate, 200 lb. sulphate of potash, and 100 lb. each of sulphate of soda and magnesia, per acre.

This mixture (Plot 5) has given an increase of about 2 bushels of corn and 1¾ cwt. of straw over the produce of the unmanured land.

Nitrogen of the Soil and Atmosphere Insufficient.—As these manures have supplied all the ash constituents of the wheat crop (excepting silica, which we shall presently see to be non-essential), it is quite evident that the amount of the other necessary elements of plant-food supplied by the soil and atmosphere has been insufficient to produce a full crop of wheat. The crop grown with a full supply of ash constituents on Plot 5 has contained, on an average, about 20 lb. of nitrogen per acre per annum. This quantity represents the average amount furnished by the soil and atmosphere without the aid of nitrogenous manure.

We shall presently see that the growth of wheat on these plots was really limited by the small quantity of nitrogen at the disposal of the crop. When nitrogen is supplied, phosphates and potash become important elements in producing growth.

Ammonium-salts with Ash Constituents.

The ammonium-salts employed have been a mixture of equal parts sulphate and chloride: 200 lb. of this mixture are estimated to contain about 43 lb. of nitrogen. The systematic experiments with ammonium-salts did not begin, in several cases, till 1852. We shall therefore take the average produce after this date as the basis of our comparison:—

TABLE III.—PRODUCE OF WHEAT VARIOUSLY MANURED, AVERAGE OF FIFTY-FIVE YEARS.

Plot.	Manuring.	Average Produce, 55 Years, 1852-1906.				Average Produce last 10 Years, 1897-1906.		
		Dressed Corn.		Straw and Chaff.	Corn to 100 Straw.	Dressed Grain.	Weight per Bushel.	Straw.
		Quantity.	Weight per Bushel.					
		bush.	lb.	cwt.		bush.	lb.	cwt.
3	No manure . . .	13	59.0	10.5	69.5	11.6	61.2	9.7
5	Mixed ash constituents	14.9	59.6	12.3	68.6	13.9	61.3	12.1
6	Do., and ammonium-salts, 200 lb. . .	23.9	60.3	21.6	62.5	21.6	61.5	21.0
7	Do., do. 400 lb.	32.8	60.3	33.0	56.4	31.0	61.6	33.2
8	Do., do. 600 lb.	37.1	60.1	40.9	51.7	38.6	61.0	44.0
10	Ammonium-salts, 400 lb.	20.4	58.2	18.5	62.6	18.8	60.4	17.0
11	Superphosphate and ammonium-salts, 400 lb.	23.5	58.2	22.5	59.6	18.6	59.5	19.0
2	Farmyard manure, 14 tons. . . .	35.5	60.7	34.3	58.8	36.6	61.7	40.1

Table III. shows, that whereas the continued use of ash constituents alone increased the crop by less than 2 bushels, the addition of 200 lb. of ammonium-salts gave a further increase of 9 bushels, the addition of 400 lb. of ammonium-salts an increase of 17.9 bushels, and the addition of 600 lb. an increase of 22.2 bushels. The produce with ash constituents and 400 lb. ammonium-salts (Plot 7) nearly equals the produce from the annual application of 14 tons farmyard manure; while the produce with 600 lb. of ammonium-salts (Plot 8) exceeds both in corn and straw that yielded by the dung. The far greater effect produced by the nitrogen of the ammonia than by the nitrogen of the dung is very evident, *86 lb. of nitrogen as ammonia being on a long series of years nearly equal to 200 lb. applied as dung.*

Organic Manures Unnecessary.—

These results throw a flood of light on the conditions required for producing good wheat crops. The manure applied to these ammonia plots has been purely inorganic,—it has contained no carbon; yet the produce has been large, and in favourable seasons very large. In 1863 the yield of corn on Plot 7 amounted to 53½ bushels per acre. About 1 ton of carbon is contained in the average crop of Plot 7, and still more in that of Plot 8. All the carbon assimilated by these crops has been derived from the atmosphere. *The atmospheric supply of carbon is apparently sufficient for the largest cereal crops.* Such crops may be obtained in favourable seasons by the use of purely inorganic manures.

Silica Unnecessary.—The results are equally conclusive as to the uselessness of applying silica in manure. The composition of cereal crops (p. 326, vol. i., Div. ii.) shows silica to be by far the largest constituent of the ash of straw, and to its presence the stiffness of the straw has been too hastily attributed. Many experiments have shown that silica is not an indispensable constituent of cereal crops, that fully developed plants can be obtained without it, and that in these plants the straw does not show any want of stiffness.

At Rothamsted, wheat crops, above the average produce of the country, have been continuously obtained for sixty years with manures supplying no silica. The produce with these manures has indeed been larger than that yielded by farmyard manure which supplies silica. To make the test still more complete, one-half of several of the plots received for four years an application of soluble silicates, and in the succeeding twelve years the straw of the crop was returned to the land. The half plots thus treated have not shown any increase of produce, save in those cases where the straw was helpful by supplying potash; nor had the wheat-straw so grown any greater power of standing in rough weather than that grown without silica in the manure.

Artificial Supply of Nitrogen essential for Wheat.—The evidence afforded by these experiments with ammonium-salts shows unmistakably the great need of the wheat crop for an artificial supply of nitrogen, if full crops are to be continuously obtained. The assimilable nitrogen furnished by the air and rain is quite insufficient for the production of a full cereal crop. The annual application of 86 lb. of nitrogen per acre, in the form of ammonia, has raised the average produce from 14.9 bushels to 32.8 bushels per acre.

Manures best for Cereals.—The manures which experience has proved to be most effective for wheat, barley, or oats, are those which, like guano, nitrate of soda, and sulphate of ammonia, supply nitrogen in a form readily assimilated by plants. The enrichment of the surface-soil with nitrogen is also the main effect of a variety of agricultural methods commonly employed to render land fit to produce good crops of cereals.

Excessive Dressings Unprofitable.—It will be noticed that the application of 200 lb. of ammonium-salts per acre gave an average increase of 9 bushels of corn and 9¼ cwt. of straw. The addition of a second 200 lb. of ammonium-salts gives a further increase of nearly 9 bushels of corn and 11⅜ cwt. of straw. The 400 lb. of ammonium-salts was thus not an excessive dressing under the conditions of the experiment—*i.e.*, continuous cropping with wheat. When wheat is grown in a rotation, when the land is enriched by occasional use of farmyard manure, and by the growth of clover, &c., no such quantity of nitrogenous manure is needed. With a further addition of 200 lb. ammonium-salts, however, the return is greatly diminished, the increase only amounting to 4.3 bushels of corn and 7.9 cwt. of straw. It is plain, therefore, that 600 lb. was not an economical dressing.

For thirteen years, 1852-64, as much as 800 lb. of ammonium-salts were applied to one of the plots. The average produce of different amounts of ammonia during these thirteen years is shown in Table IV., p. 8.

We have here a successive increase of 10¼, 8⅝, 1¾, and ⅝ bushels of corn, and 10½, 11, 4⅝, 3⅞ cwts. of straw for each additional 200 lb. of ammonium-salts.

Corn and Straw from High Manuring.—It will be observed that there is a much larger increase of straw than of corn with the heavier dressings of am-

monium-salts: the proportion of corn to straw diminishes, indeed, with each addition of ammonia.

The quality of the corn is improved by the use of 200 lb. and 400 lb. of ammonium-salts, but with further additions of ammonia the weight per bushel begins to decline.

TABLE IV.—PRODUCE OF WHEAT WITH VARIOUS QUANTITIES OF AMMONIUM-SALTS, AVERAGE OF THIRTEEN YEARS (1852-64).

Plot.	Manuring.	Dressed Corn.		Straw and Chaff.	Corn to 100 Straw.
		Quantity.	Weight per Bushel.		
		bush.	lb.	cwt.	
5	Mixed ash constituents . . .	18¼	58⅛	16⅝	62.6
6	Do. with ammonium-salts, 200 lb. .	28½	58⅞	27⅛	58.8
7	,, ,, ,, 400 lb. .	37⅛	58¾	38⅛	54.6
8	,, ,, ,, 600 lb. .	38⅞	58¼	42¾	51.2
16	,, ,, ,, 800 lb. .	39½	58	46⅜	47.8

Ammonium-salts alone.

We come now to Plot 10, which has received annually 400 lb. of ammonium-salts, without any supply of phosphates, potash, magnesia, lime, or other ash constituents (saving the sulphuric acid and chlorine in the ammonium-salts). This treatment has dated from 1845. The average produce in fifty-five years has been 20.4 bushels and 18.5 cwt. of straw; or 7.4 bushels and 8 cwt. of straw over that of the unmanured land.

Natural Supplies of Ash and Nitrogen.—While the crop on Plot 5 was entirely dependent upon natural sources of nitrogen, the crop on Plot 10 has been wholly dependent upon natural sources for its ash constituents. The supply of ash constituents from the soil has clearly been insufficient, for the same amount of ammonium-salts, when aided by a manuring of ash constituents (Plot 7), has produced a much larger crop than on Plot 10.

The natural supply of ash constituents, though insufficient, is, however, more effective than the natural supply of nitrogen; for while, on Plot 5, the natural supply of nitrogen only produces 14.9 bushels, the natural supply of ash constituents is equal to the production of 20.4 bushels.

Soils better supplied with Ash than with Nitrogen.—The fact just stated is one that holds true in general agricultural experience. A purely nitrogenous manure will, in a vast majority of cases, produce a greater effect on wheat or other cereals than any manure supplying ash constituents,—not because the latter are less necessary for the growth of the crop, but because the soil is generally far better supplied with available ash constituents than it is with available nitrogen.

It must be remembered, also, that the average results obtained in these Rothamsted experiments with purely nitrogenous manures are by no means so good as would be obtained in ordinary practice. The soil on Plot 10 is now in fact exhausted of ash constituents by sixty-two successive wheat crops, removing at least 20 lb. of potash and 12 lb. of phosphoric acid per acre per annum. In the earlier years of the experiment the ammonium-salts applied alone gave a much better result than they do at present.

Importance of Ash Constituents.—The importance of ash constituents when nitrogen is supplied is strikingly shown by comparing the produce of the exhausted soil on Plot 10 with that of the soil of Plot 7, which has annually received an abundance of ash constituents, with the same amount of ammonia. The average produce with ash constituents and ammonia is 12.4 bushels greater than with the same quantity of ammonia applied alone. *As nitrogenous manures are by far the most costly that a farmer purchases, it is important to remember that economy in their use depends a great deal on there being a sufficient*

supply of available phosphates and potash in the soil.

Ammonia with Individual Ash Constituents.

On Plot 11 the 400 lb. of ammonium-salts have been continuously applied with superphosphate. The average produce is 23.5 bushels and 22.5 cwt. of straw, or 3.1 bushels and 4.0 cwt. of straw more than that given by the ammonium-salts alone. Thus, on a phosphate-exhausted soil, superphosphate becomes a paying manure for wheat if nitrogen is not deficient.

The produce on this plot is, however, far below that on which *all* the necessary ash constituents are applied. The *superphosphate* has increased the produce of the ammonia by 3.1 bushels, but the *mixture of ash constituents* applied on Plot 7 increases the produce by 12.4 bushels. The mixed ash constituents include potash, soda, and magnesia.

A series of experiments has been made in which the sulphates of potash, soda, and magnesia have been used separately, each with ammonium-salts and superphosphate. In the earlier years of the experiments there was a great reserve of potash in the soil, partly natural and partly due to previous manurings, and this potash was so rendered available by the action of the soluble sulphates of magnesia and soda that all three plots gave much the same results. Table V., however, shows the results for the ten years, 1893-1902, when the original potash in the soil had become largely exhausted, and proves that neither magnesia nor soda can take the place of potash in a manure. That the action of the magnesia or soda is indirect may be seen from the fact that the sulphate of magnesia on Plot 14 does not increase the amount of magnesia in the ash, but does cause an increase in the quantity of potash taken up from the soil.

TABLE V.—PRODUCE OF WHEAT VARIOUSLY MANURED, AVERAGE OF TEN YEARS (1893-1902).

Plot.	Manured with Ammonium-salts and Superphosphate.	Total Corn.	Straw and Chaff.
		lb.	lb.
11	Alone	1299	2150
12	With soda	1760	2822
14	With magnesia	1641	2684
13	With potash	1938	3342
7	With soda, magnesia, and potash	2076	3606

Relative Importance of the Ash Constituents. — *Phosphoric acid* and *potash* are the ash constituents of the greatest importance to the wheat crop, and indeed to every other crop. *Magnesia* is a less important ash constituent of wheat, and is usually found in sufficient abundance in the soil. *Soda* is found to a very small extent in the mature crop, but soda salts have some effect as manure: they act by liberating potash in the soil. *Lime* scarcely occurs in wheat grain, and to only a small extent in the straw; the natural supply is quite sufficient.

Effect of Autumn and Spring Applications of Ammonium-salts.

Up to the year 1872 the whole of the manures, with the exception of nitrate of soda, were applied to the land in autumn at the time of wheat-sowing, and ploughed in.

With the season 1872-73 an experiment commenced on the comparative effect of autumn and spring applications of ammonium-salts. For five years (1873-77) Plot 15 received 400 lb. of ammonium-salts as a top-dressing at the end of March or beginning of April, while Plot 7 received the same amount when the wheat was put in in October. For the autumn of 1877 the manuring was reversed: Plot 15 now received the ammonium-salts in the autumn, and Plot 7 received them in the spring. Both plots had at all times a complete autumn manuring with ash constituents.

The comparative results in ten years of autumn and spring manuring are shown in Table VI.

TABLE VI.—COMPARATIVE EFFECT OF AUTUMN AND SPRING SOWING OF AMMONIUM-SALTS.

	Rainfall.		Drainage, 5-ft. Gauge.		Total Produce, Corn and Straw.		
	Autumn Manuring to Spring Manuring.	Spring Manuring to end of July.	Autumn Manuring to Spring Manuring.	Spring Manuring to end of July.	Autumn Manuring.	Spring Manuring.	Spring + or − Autumn.
	inches.	inches.	inches.	inches.	lb.	lb.	lb.
1872-73 . .	18.53	6.92	11.45	0.42	3344	5031	+1687
1873-74 . .	7.05	7.93	2.89	0.58	7094	4588	−2506
1874-75 . .	10.55	13.55	5.21	3.86	5110	4915	− 195
1875-76 . .	12.17	7.58	10.14	1.94	3793	4083	+ 290
1876-77 . .	22.01	8.18	15.78	1.18	3048	4795	+1747
1877-78 . .	11.17	12.96	8.11	6.02	4486	7017	+2531
1878-79 . .	15.05	17.10	13.09	6.76	1275	4063	+2788
1879-80 . .	5.78	10.82	3.37	1.58	6309	6155	− 154
1880-81 . .	15.20	6.16	12.75	0.25	3489	3917	+ 428
1881-82 . .	10.34	14.73	7.62	4.48	5948	7981	+2033
Mean . .	12.79	10.59	9.04	2.71	4390	5255	+ 865

Spring Sowing preferable.—It appears that, out of the ten seasons, there was one (1874) in which the autumn sowing of the ammonium-salts gave decidedly the best results; there were four in which the difference between autumn and spring sowing was very small; there were five in which the spring sowing gave much the best result. The average result was thus decidedly in favour of spring sowing.

Rainfall and Time of Sowing Manure.—When we turn to the other columns in the table, it is plainly seen that the advantage or disadvantage of autumn sowing depends on the amount of the rainfall. The autumn application of ammonium-salts is advantageous only when a dry winter follows their application. *This is owing to the fact that ammonia is converted into nitrates in the soil; and the soil having no power of retaining nitrates, they are liable to be washed into the subsoil by heavy rain, and to be carried in drainage-water beyond the reach of the roots.* This is what happens during a wet winter.

In the table, the quantity of rain, and the amount of drainage-water passing through 5 feet of uncropped soil (60-inch drain-gauge), in each season, are given.

It will be noticed that a wet winter, in some cases (1880-81), does little harm to the autumn-sown ammonium-salts. In these cases the wet winter is followed by a dry summer, and the crop is able to draw up from the soil the solution of nitrates which had passed downwards.

The worst results of autumn manuring are when a wet winter is followed by a wet summer (1877-78, 1878-79, 1881-82). In these cases the nitrates washed below are kept down by the subsequent spring and summer rainfall.

In consequence of these results, the time for applying the ammonium-salts to the experimental plots in the wheat-field has been altered. For 1878-83 the ammonium-salts were (save on Plot 15) applied entirely in the spring. Since then 100 lb. of ammonium-salts have been applied in autumn and the remainder in spring.

With Nitrate of Soda.

The trials with nitrate of soda commenced in 1852, but certain variations have been made from time to time in the quantities used, so that Table VII. shows the results of the ten years 1893-1902 only. As one object of the experiment was to compare the effect of nitrogen in the two forms of *ammonia* and *nitric acid*, the quantity of nitrate of soda employed was arranged to supply the same weight of nitrogen (43 and 86 lb.) as 200 lb. and 400 lb. of ammonium-salts. The nitrate of soda has always been applied as a top-dressing at the end of March or beginning of April.

TABLE VII.—PRODUCE OF WHEAT WITH NITRATE OF SODA AND AMMONIUM-SALTS, AVERAGE OF TEN YEARS (1893-1902).

Plot.	Manure.	Dressed Corn.		Straw.	Corn to 100 Straw.
		Quantity.	Weight per Bushel.		
		bush.	lb.	cwt.	
3	No manure	12.7	61.2	9.3	76.1
5	Mixed ash constituents . .	15.4	61.4	11.8	74.7
6	,, ammonium-salts, 200 lb. .	23.5	61.6	20.2	66.8
9	,, nitrate of soda, 275 lb. .	27.3	61.3	25.5	60.9
7	,, ammonium-salts, 400 lb. .	32.4	61.4	32.2	57.6
16	,, nitrate of soda, 550 lb. .	32.5	61.0	33.3	55.6

Nitrate of Soda excels Ammonium-salts.—From these results it will be seen that nitrate of soda is at Rothamsted a more effective source of nitrogen for wheat than the ammonium-salts, the straw being more particularly responsive to the nitrate of soda dressings. When 43 lb. of nitrogen are used the nitrate yields 16 per cent more grain and 26 per cent more straw than the equivalent amount of ammonium-salts: 86 lb., however, yields practically the same grain, and only about 1 cwt. more straw. It should be remembered that the soil of the Broadbalk field is well provided with carbonate of lime, hence the injurious effects arising from the acidity produced by the continuous use of ammonium-salts on some soils is not here apparent. The superiority of the nitrate with wheat is probably due to the fact that it remains soluble, thus diffusing deep into the soil and encouraging a greater range of roots.

Influence of Rainfall.—Ammonium-salts and nitrate of soda compare, however, very differently in different seasons: there are seasons in which the nitrate is immensely superior, and there are some seasons in which the ammonium-salts give an equal or better result. With a dry spring and summer the nitrate is generally much superior to a spring dressing of ammonium-salts, the nitrate being immediately available to the plant, while the ammonium-salts have to undergo the process of nitrification, which in dry weather is not speedy. On the other hand, in a wet spring the nitrate is subject to immediate loss by drainage, while the ammonium-salts are not lost till they are nitrified, and thus for a few weeks partially escape the losses which the nitrate is undergoing. While this may be generally true, it is found that in exceptional seasons the relative position of the two manures is reversed. In an exceptionally dry season, such as 1893, the ammonium-salts give a better return than the corresponding nitrate of soda, whereas in continuously wet summers, such as 1879 and 1903, the nitrate of soda, despite its tendency to wash out of the soil, produces much the better crops. Doubtless this is due to the fact that the conversion of ammonium-salts into nitrates is greatly delayed by the low temperature and deficient aeration prevailing in the soil during a wet summer, so that the ready-formed nitrate is of greater advantage to the plant. The evidence is even in favour of the nitrate of soda generally in the wetter seasons, as may be seen from Table VIII., where thirty years' results have been divided into two groups according as the rainfall was above or below the average. In the dry seasons the yield from ammonium-salts was 86.6 per cent of that from nitrate of soda; in the group of wet seasons the ammonium-salts were less effective, and only yielded 78.8 per cent of the grain produced by the nitrate of soda. The question of the relative value of these two sources of nitrogen is complicated by several factors, which will vary from soil to soil: for example, the unfavourable action of nitrate of soda upon the tilth of the land will have its greatest influence in a dry season upon a comparatively heavy soil such as that of Rothamsted

TABLE VIII.—COMPARISON OF THE YIELD OF DRESSED GRAIN WITH NITROGEN AS AMMONIUM-SALTS OR NITRATE OF SODA, IN SEASONS WHEN THE RAINFALL WAS BELOW OR ABOVE THE AVERAGE, THIRTY YEARS (1873-1902).

	Rainfall.	Dressed Grain per acre.		Ratio of yield by Ammonium-salts to that of Nitrate of Soda = 100.
		Plot 9a. Nitrate of Soda.	Plots 6 & 7. Ammonium-salts.	
	inches.	bush.	bush.	
14 seasons *below* average rainfall .	24.23	30.6	26.5	86.6
16 seasons *above* average rainfall .	33.13	32.1	25.3	78.8

Proportion of Corn to Straw.

In Tables III. and VII. will be found the proportion of corn to 100 straw in the produce of the various manures we have considered. The proportion of corn is highest in the produce of the unmanured land, and on that receiving only the ash constituents of the wheat crop.

The addition of any manure producing luxuriance of growth increases the proportion of straw: thus, by the continuous application of farmyard manure, the proportion of corn to 100 straw falls from 69.5 to 58.8.

With increasing quantities of ammonium-salts, applied with ash constituents, the proportion of corn gradually falls, being 62.5, 56.4, and 51.7, with 200, 400, and 600 lb. of ammonium-salts. This considerable increase in the proportion of straw with the higher amounts of ammonium-salts is not, however, entirely due to the ammonium-salts, as on Plot 10, with 400 lb. of ammonium-salts alone, the proportion of corn is 62.6; and on Plot 11, with the same quantity of ammonium-salts with superphosphate, the proportion is 59.6 to 100. The increase in straw is clearly due in great part to the potash supplied on Plots 6, 7, and 8, which helps largely to form straw when the nitrogen necessary to nourish the crop is present.

The proportion of straw is much greater with nitrate of soda than with ammonium-salts (Table VII.)

Influence of Season.

The 64 successive wheat crops in Broadbalk field at Rothamsted, grown for the most part under the same conditions as to manuring every year, afford splendid material to the statistician for indicating the varying produce of the country in different seasons. We cannot in this place regard them in this wide aspect. The produce of each plot, and the character of each season, during 40 years, will be found in two papers by Messrs Lawes and Gilbert, in *Jour. Royal Agric. Soc.*, 1864, 93; 1884, 391. To these papers, and to a paper, "Our Climate and our Wheat Crops," *ibid.*, 1880, 173, we must refer for full details of the earlier years. Certain other effects of season upon yield are discussed in a paper by A. D. Hall in the *Journal of the Board of Agriculture*, 1905, ii. 716. We have here to regard the influence of season as a condition affecting the fertility of soil and the action of manures.

Every farmer knows that the effect of season is greater than the effect of manure. A season may be so bad that the best soil and manure may yield a miserable produce, and it may be so good that moderate manuring may nearly equal in result a liberal treatment. A suitable manuring will, however, assert itself in a large majority of cases, redeeming a bad season from utter loss, and securing from a good season the grand return which it is capable of yielding.

Influence of Light and Heat.—No large crop can be obtained without a sufficient amount of light and heat, as the assimilation of carbon from the atmosphere only occurs with suitable light and temperature. The formation of seed especially requires heat. A bulky crop in June will produce abundance of corn in July, if this month is warm and not too wet; but it will remain a crop of

straw if July is cold and rainy. The corn produced in a cold wet summer is also imperfectly developed: it contains less starch, and a larger proportion of albuminoids and ash constituents, than well-ripened grain, and has a low weight per bushel. The same defect in the corn may be brought about by premature ripening, occasioned by sudden heat and drought; but this will seldom happen upon a clay soil like that at Rothamsted.

Autumn and Winter Weather.—The popular view of the character of a wheat season is confined to the meteorological conditions of spring and summer. Winter is taken into account only when frost or floods have injured the plant. We have already seen, however, when considering the very different results of the autumn and spring application of ammonium-salts, that the dryness or wetness of the autumn and winter is a most important factor in determining the character of the next summer's crop. In a wet winter, the nitrates produced in the soil since the last cropping, or resulting from autumn applications of nitrogenous manure, may be removed almost entirely in the drainage-water, and the soil reduced to an impoverished condition by the time the growth of wheat commences in the spring. A dry winter is thus essential if a full wheat crop is to be harvested throughout the country.

A detailed examination of the results would seem to show that the dryness of the late autumn and early winter months constitutes the most favourable factor towards a large wheat crop. It is at that time that the foundation is laid, and if the season is wet the crop can never recover from the adverse start: the value of a dry early winter may, however, be nullified by subsequent unfavourable conditions.

A dry period from October to January benefits the wheat plant not only by leaving in the soil the nitrates available for growth, but also by favouring the development of an extensive root-system. During the winter it is chiefly the root of the wheat plant that is forming, and should the soil be water-logged by repeated rain this growth of root becomes much restricted and unable to maintain an adequate development of leaf and stem later.

Conditions Favourable to Large Crops.—The years of greatest total produce during the Rothamsted experiments have been 1863 and 1854. These seasons had dry winters, and in the case of 1863 the winter was also mild. There was also during spring and summer a deficiency of rain, though enough fell at critical times to prevent any check to growth. The summers were not unusually hot,—indeed that of 1854 was decidedly cool; there was thus no premature ripening of the produce.

These are the conditions favourable to large produce on every description of soil, manured or unmanured. The dry weather between autumn and spring retains in the soil all the nitrates belonging to it; dry mild weather during winter and spring also occasions a maximum development of root; the plant is thus enabled to levy contributions from a considerable depth of soil. If moderately dry weather continue, the plant is afterwards fed with a concentrated solution of plant-food. The moderate warmth of the season allows full time for the collection of food from the soil. There is finally a somewhat late harvest, and a most abundant produce.

Ash Constituents and the Seasons.—During wet and cool seasons the supply of phosphoric acid has a potent effect in increasing the yield, and especially the proportion, of grain to straw. Phosphoric acid promotes the maturing processes in the plant, and has thus its greatest effect in seasons unfavourable to ripening. On the other hand, potash manures are most effective in dry, hot summers, since they tend to encourage growth and prolong the vegetative development of the plant.

Effects of Residues of Manures.

Residues of Previous Manuring.—The Rothamsted experiments supply numerous illustrations of the influence of the residues of previous manuring, and the wheat-field supplies one notable example of the relative duration of ammonium-salts and the ash constituents respectively.

The manures on Plots 17 and 18 have alternated each year since 1852. In each year one plot receives the usual full dressing of ash constituents, and the other

plot 400 lb. of ammonium-salts. In the following year the manuring is reversed: the plot that had received ash constituents now receives ammonium-salts, and the one which had received ammonium-salts now receives ash constituents. There is thus each year a crop manured by ammonium-salts plus a residue of ash constituents, and a crop manured by ash constituents plus the residue from ammonium-salts.

The average effect of these annual residues is shown in Table IX.

TABLE IX.—EFFECT OF ANNUAL RESIDUE OF ASH CONSTITUENTS, AVERAGE FIFTY-FIVE YEARS (1852-1906).

	Dressed Corn.	Straw.
	bush.	cwt.
Ammonium-salts and residue of ash constituents	30.4	29.6
Ammonium-salts alone, Plot 10 . . .	20.4	18.5
Excess, due to residue of ash constituents .	10.0	11.1

EFFECT OF ANNUAL RESIDUE FROM AMMONIUM-SALTS, AVERAGE FIFTY-FIVE YEARS (1852-1906).

	Dressed Corn.	Straw.
	bush.	cwt.
Ash constituents and residue of ammonium-salts	15.4	13.2
Ash constituents alone, Plot 5	14.9	12.3
Excess, due to residue of ammonium-salts .	0.5	0.9

The abundant residue of ash constituents remaining from the preceding year has proved its effectiveness, by raising the produce by 10 bushels per year.

We turn now to the result produced by the residue of the ammonium-salts. It has yielded, according to the table, an increase of but ½ bushel per year!

Of the 86 lb. of nitrogen contained in the ammonium-salts, not more than 43 lb. would be contained in the crop obtained by its use: what then has become of the remaining 43 lb.? It is quite clear that the missing ammonia is not present in the soil ready for use in the next season, for it produces no effect on the crop, and the evidence goes to show that the unused ammonia has been in great part lost as nitrates in the drainage-water.

Tracing the Fate of Manures.

The fate of the various manures applied to the wheat plots at Rothamsted has been studied in other ways,—by analysis of the crops that are removed and of the soil after the lapse of successive periods of years, and also by analysis of the waters flowing from the tile-drains which run below the experimental plots. The latter method gives us information as to the substances which are being lost to the soil by removal into the permanent store of subsoil-water below the reach of the plant's roots, though it is difficult to estimate the amounts so lost. The former method should enable us to strike a balance-sheet, and to distribute the manure applied between the crops, the soil, and wastage, were it not that, from the impossibility of drawing exactly representative samples of soil, only approximate estimates can be formed of the amount of any constituent present in the land at each period: furthermore, samples of soil were not taken until the experiments had been going on for some time.

Loss of Nitrates in Drainage-waters. — Considering the drainage-waters first, it has already been shown that they always contain considerable quantities of nitrates, derived from the oxidation of the nitrogen compounds, either originally in the soil or added as manure. Whatever the compound of nitrogen that is used, whether nitrate of soda, ammonium-salts, rape-cake, or dung, it only reaches the drainage-water in the form of nitrates. Even the freely soluble ammonium-salts are very rarely found in the drainage-water, and then only in small quantities, so quickly are they arrested by the soil. The nitrates, in fact, are the only compounds of nitrogen that are not held by the soil. The formation of nitrates is rapid when the conditions are favourable, as, for example, when the soil is warm and moist and has been recently stirred, but the rate of production will also depend upon the nature of the nitrogen compounds: many of those present in dung and in the original stock in the soil are extremely resistant to change. The point, therefore, which is brought out by the analyses of the drainage-water is that, even from the poorest soils, loss of nitrates can and does take place whenever there is percolation through the soil and no growing crop to utilise the nitrates as fast as they are formed.

On the rare occasions when the drains below the Rothamsted wheat plots have run in May, June, or July, the water was found to contain very little nitrate, because they had been utilised by the growing crop; but a heavy rainfall in October or November, after the land had been broken up and cultivated for the new crop, always gives rise to drainage-water rich in nitrates. The higher the condition of the land, as, for example, on the plot that receives farmyard manure every year, the greater will be the loss of nitrates. It has been shown that the rainfall of the autumn and early winter to a large extent determines the magnitude of the succeeding wheat crop: a heavy rainfall washes away the summer-formed nitrates, upon which the future crop must feed, and from the poor start thus occasioned the plant never recovers. This is well brought out at Rothamsted by a comparison of the wheat plot that is continuously unmanured with a pair of similarly unmanured plots which are alternately cropped and bare-fallowed, so that each only carries a crop once in two years. Taking the whole period, the wheat after fallow yields 16.9 bushels per acre, as against 12.6 bushels for wheat after wheat each year; but if the rainfall each year for the months of September to December are set out, and the crops are divided into two series according as they follow autumns of greater or less than average rainfall, it will be seen (Table X.) that after the wet autumns the average crop is no higher on the fallowed than on the continuously cropped land, whereas the dry autumns are succeeded by crops 50 per cent larger on the fallowed than on the continuous wheat plot. The summer fallowing results in the production of nitrates, which are washed out of the soil if the autumn is wet, but remain there for the benefit of the wheat crop if no percolation takes place.

TABLE X.—EFFECT OF WET OR DRY AUTUMNS ON THE INCREASE OF THE WHEAT CROP DUE TO FALLOWING (1870-1902).

	16 seasons *less* than average Rainfall.	16 seasons *more* than average Rainfall.
	inches.	inches.
Rainfall (Sept. to Dec. inclusive)	8.88	13.66
Percolation through 60″ of soil (Sept. to Dec. inclusive)	4.03	8.92
	lb.	lb.
Total produce (wheat after wheat)	1810	1627
Total produce (wheat after fallow)	2743	1757
Increase due to fallowing	933	130
Percentage increase due to fallowing	51.5	7.9

Loss of other Manurial Elements in Rain-water.—Of the other elements of plant-food the analyses show little or no loss in the drainage-waters: on Plot 5, for example, 3½ cwt. per acre of superphosphate, containing about 70 lb. of phosphoric acid, have been applied every year, yet the drainage-water from this plot contains only about 0.000091 per cent of *phosphoric acid*, so that the losses are trivial. The case is much the same for *potash:* despite the fact that this same Plot 5 receives sulphate of potash containing 100 lb. of potash annually, the drainage-water contains only about 0.00054 per cent, so that again the loss is trifling. In both phosphoric acid and potash, then, we may expect to find remaining in the soil all that has been applied as manure and not removed in the crops—an expectation that is justified by the analysis of the soil. Of *lime*, however, the drainage-water is always removing considerable quantities from the soil: from the unmanured plot it is removed as bi-carbonate, the solution of the calcuim carbonate being effected by the carbonic acid derived from the roots of the plants and the decay of the humus; but on the manured plots the loss of lime is much greater, because reactions take place between the salts applied in the manures and the compounds of calcuim in the soil, which result in the production of soluble salts of lime.

Evidence of Analyses. — Turning now to the evidence afforded by the analyses of the soils, Table XI. shows the nitrogen found in the surface-soil in 1893, calculated both as percentages and as lb. per acre: this is compared with the additions of nitrogen in manure and its removal in crops during the previous fifty years, so as to strike a rough balance-sheet of gain or loss to the land, taking the unmanured plot as a basis for comparison. The percentages of carbon are also given.

The unmanured plot has been parting with nitrogen to the crop at the rate of about 17 lb. per acre per annum. There are other unestimated losses through drainage and the removal of weeds, and these various withdrawals have resulted in the reduction of the percentage of nitrogen to 0.0992. Although the amount of nitrogen at starting is not known, yet analyses made in 1865 and 1881 show that the decline in the nitrogen has been continuous, the average fall being equivalent to about 11 lb. of soil-nitrogen per acre per annum between 1865 and 1893. This figure is subject to inevitable errors due to the impossibility of taking exactly equivalent samples of soil at the different dates, but yet it is so much less than the annual removal in the crop (about 16 lb. per acre per annum for the period in question) that we are forced to look for agencies recuperating the stock of nitrogen in the soil. In the first place there is the rain, which has been analysed month by month at Rothamsted for the last forty years, and is found to bring down nearly 5 lb. of combined nitrogen per acre per annum. This, added to the 11 lb. the soil is found to have lost, makes up the 16 lb. removed in the crop, but there are still the unknown losses by drainage and the removal of weeds to be accounted for. A little nitrogen is doubtless fixed by leguminous weeds growing on the plot, *medicago* being rather an abundant weed in certain seasons; but the bulk of the restoration of nitrogen is probably due to the bacterium *azotobacter*, an organism capable of fixing nitrogen without the intervention of a leguminous plant, and which has been found in all the Rothamsted soils. That it has not been more effective on the arable land is due to the complete removal of the crop there, thus leaving little or no organic material to serve as a source of energy for the *azotobacter*, which can only fix nitrogen when it is oxidising some carbonaceous material.

Natural Restoration of Nitrogen.—The possibility of recuperative agencies restoring nitrogen to arable soils is still obscure, but some light is thrown upon the question by the examination of a portion of the same field which was under arable cultivation until 1885, and was then left entirely to itself until it has become covered with self-sown grasses and weeds, which are never removed, but allowed to remain as they fall in the autumn. On examining the soil of this part of the field after twenty years of being left to itself, it was found to have gained nitrogen at a rate of 100 lb. per acre per annum,—far more than would

be accounted for by the proportion of leguminous herbage present. It is, however, probable that the *azotobacter*, being in this case supplied with carbonaceous material from the *débris* of the vegetation, has been able to fix nitrogen in the large quantities indicated by the analyses. In the soil of the plot receiving ash constituents only (except for a little nitrogen in the first eight years of the experiments) there is a slightly larger proportion of nitrogen, representing the *débris* of the rather larger growth of crop on this plot, as may be seen from the fact that the percentage of carbon in the soil is also higher than on the unmanured plot. The differences, however, are small, nor is the amount of nitrogen very much greater on Plots 7 and 9, receiving a complete manure containing large amounts of nitrogen every year. The nitrogen is, however, supplied as ammonium-salts or as nitrate of soda: the latter is not retained by the soil, the former is also rapidly transformed to nitrates, hence both plots are subject to loss by drainage.

Residues of Nitrogen not Accounted for.—Of 4100 lb. of nitrogen supplied as ammonium-salts only 2360 have been recovered in the crop, the soil has been protected from loss to the extent of about 600 lb., but there is still 1990 lb. unaccounted for in either soil or crop, most of it having been washed out. The recovery of nitrogen from nitrate of soda by the crop is rather more complete, some 2700 lb. being harvested from 3570 lb. applied, but again the loss is great, 1210 lb., mostly by drainage. It is, however, on the dunged plot that the recovery of the applied nitrogen is most imperfect: something like 10,000 lb. have been put on during the fifty years of the experiment, of which only 2600 have been returned in the crop and 730 lb. stored up in the soil. Thus 5670 lb. of nitrogen—more than half of the whole that has been applied—has been lost entirely, the loss being in this case not so much due to the washing out of nitrates as to the action of bacteria, which destroy nitrogen compounds and liberate the nitrogen as a free gas.

TABLE XI.

Plot.	Manuring.	In soil 9″ deep, 1893.			Approximate supply of Nitrogen in Manure.	Approximate removal of Nitrogen in Crops.	Surplus of Nitrogen over Plot 3 unaccounted for in Soil or Crop.
		Carbon per cent.	Nitrogen.				
			Per cent.	Per acre.			
			1844-93.				
		%	%	lb.	lb.	lb.	lb.
3	Unmanured	0.888	0.0992	2,570	...	850	...
5	Ash constituents only . .	0.931	0.1013	2,630	590	1,180	200
7	Ash constituents and ammonium-salts . . .	1.101	0.1222	3,170	4,100	2,360	1,990
9	Ash constituents and nitrate of soda	1.162	0.1189	3,080	3,570	2,700	1,210
2	Farmyard manure . . .	2.230	0.2207	5,150	10,000	2,600	5,670

THE FATE OF MINERAL CONSTITUENTS.

Turning to the mineral constituents of the plants' food, the fate of the phosphoric acid applied to the Broadbalk soil has been studied in some detail. Dyer examined the samples taken in 1893, extracting the phosphoric acid in both soils and subsoils by means of strong hydrochloric acid as well as by a 1 per cent solution of citric acid. He was able to show that the subsoils of the various plots were very much alike as regards their phosphoric acid content, but that the surface-soil (0-9 in.) on the plots receiving phosphoric acid was richer in phosphoric acid by an amount practically equivalent to what had been supplied in the manure and not removed in the crop. His analyses went to show that the phosphoric acid supplied in the manure (superphosphate) had all been retained in the top nine inches of soil except as far as it had been taken up by the crop, but that none of it had been

washed out or gone even lower down into the subsoil. This conclusion was confirmed by a later examination, when the soils were extracted repeatedly with fresh portions of citric acid solution, which process resulted in the recovery from the surface-soil of the whole of the phosphoric acid supplied since the beginning of the experiments, as shown in the following Table XII.:—

TABLE XII.

	Phosphoric acid, lb. per acre.			
	Supplied in Manure.	Removed in Crop.	Surplus.	Dissolved by 5 extractions with 1 % citric acid.
Broadbalk, Plot 3. Unmanured. . .	0	550	...	565
,, Plot 5. Ash constituents only .	3960	790	3170	3000
,, Plot 7. Ash constituents + ammonium-salts . .	3810	1370	2440	2470
,, Plot 2*b*. Farmyard manure .	4870	1650	3130	2060

From these and other results of the same kind, it may be concluded that when superphosphate (the most soluble of the phosphatic manures) is applied to the land, whatever phosphoric acid the crop does not immediately utilise is retained by the surface-soil, and retained also in a readily available form, as shown by its solubility in dilute citric acid solution. Dyer also determined the potash present in the soils and subsoils of the same plots, and found that it was washed down a little farther into the subsoil, so that after fifty years the second and even the third depth of nine inches had become enriched in potash by its application at the surface. Of actual loss by washing completely through the soil there was little evidence.

Behaviour of Lime in the Soil.

Though lime is hardly to be counted as a manure, yet its actions in the soil are so important that a brief summary may be given here of the very interesting evidence as to its duration in the soil that is afforded by the Rothamsted plots. On the Rothamsted estate, as has already been indicated, the lime, or more strictly calcium carbonate, in the soil is of artificial origin, having been dug from some 12 to 20 feet below, and spread upon the surface in large quantities at various times during the seventeenth and eighteenth centuries. On the adjacent common, on the woodlands, and even on many of the grass fields of the estate, the soil contains no appreciable quantity of calcium carbonate, nor does the subsoil of the arable fields. As the calcium carbonate applied is all located in the surface layer, an examination of the soil samples taken at different dates gives an opportunity of estimating the rate at which this valuable substance is being removed from the soil, either by natural causes or by the action of the manures also applied. In the first place, there is no evidence that the lime sinks in the soil, as it is popularly supposed to do: such sinking only takes place on pasture-land, where lime, stones, or anything else on the surface is steadily buried year by year by the action of earthworms. On the arable land the lime has never descended below the layer stirred by the plough, and none is found in the sample taken between 9 and 18 inches, though something like a hundred years must have elapsed since the lime was put on the land.

On the unmanured plot the loss of carbonate of lime by purely natural causes—*i.e.*, by solution in the rain-water—amounts to 800-1000 lb. per acre per annum. This loss is much increased

by the use of ammonium-salts as manures. A dressing of sulphate of ammonia will reduce the chalk in the soil by nearly its own weight, and as may be seen on some of the Rothamsted grass plots and on the wheat and barley plots at Woburn, its repeated use will so remove the chalk as to render the soil eventually acid to test-paper and incapable of carrying crops. On the other hand, superphosphate, though itself an acid manure, occasions no great loss of carbonate of lime; while nitrate of soda and farmyard manure actually reduce or repair the losses which would otherwise be occasioned by the percolating rain-water.

CONTINUOUS GROWTH OF BARLEY.

The experiments at Rothamsted on the continuous growth of barley were begun in the Hoos field in 1852. The arrangement of the plots and the manures applied to each plot have practically been unchanged since, so that the plots to-day show the effects of more than fifty years' continuous growth of barley under the same treatment year after year.

Manures Applied.—The manures are sown in the spring, and ploughed in about a week or a fortnight before seeding. The plots do not run the whole length of this field, as in Broadbalk. Instead, there are four longitudinal strips receiving different combinations of the mineral manures; these are all crossed by four breadths receiving different nitrogenous manures. The mineral manuring on the strips is as follows: (1) none; (2) phosphoric acid only, no potash or alkali salts; (3) potash, magnesia, and soda, no phosphoric acid; and (4) complete mineral manure, supplying both phosphoric acid and the alkaline salts. Each of these is combined with the four different cross-dressings of nitrogenous manures—O. no nitrogen, A. ammonium-salts, N. nitrate of soda, and C. rape-cake. There are other plots, one of which has received farmyard manure each year, and a second which received farmyard manure for the first twenty years, but has since been unmanured.

Table XIII. (p. 20) shows the average production of grain and straw for the whole period, for the last ten years, and for the single year 1902.

Maintenance of Yield under the Continuous Growth of Barley on the same Land.—One of the plots, 1-0, has been without manure since the beginning of the experiments. Under the continuous barley-growing the decline in production has been much more marked than on the wheat plot similarly treated, the average crop having been only 10 bushels for the last ten years, against an average of more than 15 bushels for the whole period. The more limited root-range of the plant would bring about a complete exhaustion of the available soil much sooner with barley than with wheat, but there is evidence that the decline in the yield of these barley plots is to some extent due to other factors than soil exhaustion, since the continuously dunged plot, which must be gaining in fertility, also shows a steady decline in production for each of the last four decades.

Effect of Nitrogenous Manures.—The effect of nitrogenous manures upon the barley crop is best seen by comparing the yields of the various Plots 4, all of which receive the same mineral manures. Plot 4-0, receiving no nitrogen, has only given an average crop of 20.4 bushels per acre, and this has been more than doubled by the application of 43 lb. of nitrogen per acre to the other three plots. But little difference is seen in the return for this amount of nitrogen, whether it be applied as ammonium-salts, nitrate of soda, or rape-cake. Over the whole period the nitrate of soda gives the highest return by about 3 per cent, but during the last two decades the plot receiving ammonium-salts has been slightly the best of the three. In the straw, again, the differences are very small, though the superiority of nitrate of soda is rather more pronounced with the straw than with the grain. The fact that ammonium-salts answer better with barley than with wheat is due to their retention by the soil close to the surface: the comparatively shallow-rooted habit of barley and its growth during the warmer portion of the year when nitrification is active, renders such a surface accumulation of nitrogen as readily

available to the plant as the nitrate of soda itself.

On the completely manured plots the rape cake, 4 C, is not quite so effective as the more active forms of nitrogen, giving over the whole period an average yield of 41 against 43.5 and 42.1 bushels of grain.

TABLE XIII.—EXPERIMENTS ON BARLEY, HOOS FIELD. PRODUCE OF GRAIN AND STRAW PER ACRE. AVERAGES OVER FIFTY-ONE YEARS (1852-1902), AND OVER TEN YEARS (1893-1902). ALSO PRODUCE IN 1902.

Plot.	Abbreviated Description of Manures.	Dressed Grain.			Straw.		
		Average, 51 years (1852-1902).	Average, 10 years (1893-1902).	Season 1902.	Average, 51 years (1852-1902).	Average, 10 years (1893-1902).	Season 1902.
		bush.	bush.	bush.	cwt.	cwt.	cwt.
1 0	No minerals, and no nitrogen	15.3	10.1	14.3	8.8	6.4	5.6
2 0	Superphosphate only, do.	20.1	13.6	21.7	10.2	7.8	9.9
3 0	Alkali salts only, do.	16.1	8.9	13.3	8.9	5.9	6.3
4 0	Complete minerals, do.	20.4	12.4	18.2	10.8	8.0	10.9
1 A	Ammonium-salts alone	26.5	16.2	21.7	14.9	10.5	9.7
2 A	Superphosphate and ammonium-salts	39.9	26.8	39.8	22.5	16.5	20.8
3 A	Alkali salts and do.	29.4	20.8	20.0	17.0	12.9	10.4
4 A	Complete minerals and do.	42.1	35.1	40.3	24.9	20.5	23.1
1 N	Nitrate of soda alone	30.4	20.5	25.1	18.1	14.4	14.1
2 N	Superphosphate and nitrate of soda	44.0	35.9	45.9	26.2	23.0	26.1
3 N	Alkali salts and do.	31.5	23.4	22.0	19.7	15.3	10.0
4 N	Complete minerals and do.	43.5	34.9	36.5	27.4	22.6	23.4
1 C	Rape-cake alone	39.2	31.0	38.7	22.4	18.4	20.5
2 C	Superphosphate and rape-cake	41.5	33.2	41.4	23.9	19.6	24.2
3 C	Alkali salts and do.	37.7	29.6	39.7	22.4	18.1	22.7
4 C	Complete minerals and do.	41.0	32.5	40.7	24.5	20.1	25.4
7-1	Unmanured (after dung 20 yrs, 1852-71)	27.0[1]	19.9	27.5	15.4[1]	12.8	14.3
7-2	Farmyard manure	47.6	42.6	42.4	29.1	28.8	27.4

[1] Average, 31 years (1872-1902).

The plot receiving farmyard manure, 7-2, gives a higher crop than any other, but the amount of nitrogen supplied in this case is very high, being estimated at nearly five times as much as on any of the other plots.

Effect of Mineral Manures. — The great importance of phosphoric acid to the barley crop is seen on comparing Plots 3 and 4, which only differ from one another in the omission of phosphoric acid on Plots 3. It will be seen that Plots 3 give but little more crop than Plots 1, which receive nitrogen alone —only 32.9 bushels per acre against 32, taking the average of the three series A, N, and C,—but that a very marked increase to 42.2 bushels per acre is found on Plots 4 for the addition of phosphoric acid. The straw shows just as marked an increase of crop brought about by phosphoric acid as does the grain, rising from 19.7 cwt. to 25.6 cwt. per acre. In the field the most striking effect is seen in the hastened maturity brought about by the phosphoric acid. Not only are Plots 2 and 4, which receive phosphoric acid, in the ear long before Plots 3 and (to a less extent) Plots 1, but they will have begun to yellow for harvest when Plots 3 still show only upright green ears.

Comparing Plots 2 and 4, we see that a manure supplying phosphoric acid and

nitrogen is almost as effective as a complete manure containing also potash and the other alkaline salts. There is a great increase of crop caused by the superphosphate and nitrogen on Plots 2, over the nitrogen alone on Plots 1, and very little further increase for the further addition of potash and other alkaline salts on Plots 4. Where the nitrogenous manure is nitrate of soda or rape cake, the omission of the potash on Plots 2 compared with Plots 4, receiving a complete manure, shows no effect, whether we make the comparison over the whole period or for successive ten-year periods.

Potash plays a less important part than phosphoric acid in the manuring of barley. Very little increase of crop has resulted from its use on the Rothamsted soil, and the only indication of the supply in the soil giving out has been seen in the last twenty years on the plot receiving superphosphate and ammonium-salts. Of course the Rothamsted soil starts with a very large original store of potash.

Speaking generally, we find that barley is much more dependent on a supply of mineral manures than is wheat, a free supply of phosphoric acid in particular being essential to its proper development.

Relation of Manuring to Quality.—In many years the barleys grown on these plots have been submitted to valuation by an expert, and a comparison of the average results obtained year by year leads to the following conclusions. The first thing that becomes apparent is that it is impossible to grow high-class barley by simply starving the plant. It is found that the barley showing the highest average value, the best weight per bushel, the largest grains, and the smallest proportion of tail corn, is that grown on Plots 4, where a complete manure containing both nitrogen and minerals is supplied. It does not, however, follow that any kind of manure will improve the quality of the barley. The grain from the plot receiving farmyard manure every year, despite the high weight per bushel, and the bold berry indicated by the high weight of 100 grains, has yet a value considerably below the average. Again, the use of nitrogen alone on Plot 1 A or 1 N gives the lowest weight per bushel and the lowest valuations of the whole series. It has already been seen that the yield of the barley crop is very dependent on the supply of minerals, especially of phosphoric acid, and the same effect extends to the quality of the crop. The use of superphosphate on Plots 2 as compared with Plots 1 gives a better proportion of grain to straw, a higher weight per bushel, and a greatly increased value; similarly, the omission of superphosphate on Plots 3 as compared with Plots 4 results in a deterioration of all the qualities making for value in the barley. Comparing the barley from Plots 3 and Plots 1, in the absence of superphosphate the potash salts on Plots 3 do not effect much improvement, though their presence on Plots 4 as compared with Plots 2 results in an improved quality. The presence of potash in the manure increases the straw more than the grain. In all the series Plots 3 and 4, receiving potash, give a lower proportion of grain to straw than do Plots 1 and 2, without potash.

If we compare the series together, the rape-cake gives better barleys than either ammonium-salts or nitrate of soda, but the sample which on the average is the best is that grown with the full minerals and ammonium-salts.

The better quality of the barley grown with ammonium-salts as compared with nitrate of soda is doubtless due to the more shallow-rooting habit induced by the retention of the ammonium-salts near the surface. The more deeply rooted barley on the nitrate of soda plot continues to grow longer, and yields a later and more irregularly ripening crop.

Effects of Season upon Yield and Quality.—As to the effect of season, although it is noticed that in the very dry years the ammonium-salts often have the advantage, and that in very wet years the nitrate of soda is the more effective source of nitrogen, yet when averages are taken over the whole period, the seasons in which the ammonium-salts give a better crop than the nitrate of soda are wetter throughout than those in which the nitrate of soda is the more effective source of nitrogen. A wet March seems to be the most hurtful to the nitrate of soda plot. The comparative effect of the mineral manures in a

wet and dry season are also similar to those noticed in the case of the wheat. In the wet season the crop is very dependent upon supplies of minerals in the manure, and especially on an abundance of phosphoric acid.

Doubtless in the wet season the ripening effect of the phosphoric acid is specially valuable, while in a dry season the potash, by inducing a longer period of growth, is more effective in increasing the crop. The ripening action of the phosphoric acid may also be seen in the way it increases the weight per bushel of the grain in a wet season, whereas in a dry season it has little or no effect.

TABLE XIV.—MANURING OF THE PERMANENT GRASS PLOTS PER ACRE PER ANNUM, 1856 AND SINCE.

Plot.	Abbreviated Description of Manures.	Nitrogenous Manures.		Mineral Manures.				
		Ammonium-salts.	Nitrate of Soda.	Superphosphate.	Sulphate of Potash.	Sulphate of Soda.	Sulphate of Magnesia.	Silicate of Soda.
		lb.	lb.	cwt.	lb.	lb.	lb.	lb.
3, 12	Unmanured every year	...	...	...	...	...	...	...
2	Unmanured; following dung first 8 years	...	...	...	...	...	...	...
1	Ammonium-salts alone; with dung also first 8 years	200	...	...	...	...	...	...
4-1	Superphosphate of lime	...	...	3·5	...	...	...	...
8	Mineral manure without potash	...	...	3·5	...	[1]250	100	...
7	Complete mineral manure	...	...	3·5	500	100	100	...
6	As Plot 7; ammonium-salts alone first 13 years	...	...	3·5	500	100	100	...
15	As Plot 7; nitrate of soda alone first 18 years	...	...	3·5	500	100	100	...
5	Ammonium-salts alone (to 1897)	400	...	...	...	...	...	...
17	Nitrate of soda alone	...	275	...	...	...	...	...
4-2	Superphosphate and ammonium-salts	400	...	3·5	...	...	...	...
10	Mineral manure (without potash) and ammonium-salts	400	...	3·5	...	[1]250	100	...
9	Complete mineral manure and ammonium-salts	400	...	3·5	500	100	100	...
13	As Plot 9, and chaffed wheat straw also to 1897	400	...	3·5	500	100	100	...
11-1	Complete mineral manure and ammonium-salts	600	...	3·5	500	100	100	...
11-2	As Plot 11-1, and silicate of soda	600	...	3·5	500	100	100	400
16	Complete mineral manure and nitrate of soda	...	275	3·5	500	100	100	...
14	Complete mineral manure and nitrate of soda	...	550	3·5	500	100	100	...

[1] Reduced in 1905 to 100 lb.

The results indicate that in wet and cool climates, and upon heavy soils, phosphates should always form part of the manure for barley, but that potash is only likely to be valuable on light soils and in the drier parts of the country.

In the dry season the weight per bushel is much higher than in the wet, and the grain is about equal in weight to the straw, whereas in the wet season the weight of grain only amounts to about 70 per cent of the straw.

Relative Effects of Weather and Manures.—Taking the results as a whole, it is seen that season has a

much greater effect in bringing about changes in the composition of the barley grain than have variations in the manuring, but that the best barley will be grown with a fair but not large amount of nitrogenous manure combined with a free supply of phosphoric acid in some way or other.

It does not appear possible to establish any such critical periods for the rainfall in relation to the growth of barley as could be done for wheat.

TABLE XV.—PRODUCE OF HAY PER ACRE. AVERAGE OVER THE PERIOD OF FORTY-SEVEN YEARS (1856-1902), THE TEN YEARS (1893-1902), AND THE INDIVIDUAL YEAR 1905, ROTHAMSTED. TOTAL OF FIRST AND SECOND CROPS (IF ANY).

Plot.	Abbreviated Description of Manures.	Averages over		Season 1905.
		47 years (1856-1902).	10 years (1893-1902).	
		cwt.	cwt.	cwt.
3	Unmanured every year	21.9	15.9	19.4
12	Unmanured every year	24.5	18.5	24.7
2	Unmanured; following farmyard dung for first 8 years	27.9[1]	17.4	23.2
1	Ammonium-salts alone (=43 lb. N.); with farmyard dung for first 8 years	35.4[2]	24.9	26.3
4-1	Superphosphate of lime	23.3[5]	17.8	22.3
8	Mineral manure without potash	28.1	21.6	30.3
7	Complete mineral manure	38.8	36.5	52.9
6	Complete mineral manure as Plot 7; following ammonium-salts alone first 13 years	37.4[3]	36.0	46.1
15	Complete mineral manure as Plot 7; following nitrate of soda alone first 18 years	37.0[4]	40.8	51.9
5	Ammonium-salts alone=86 lb. nitrogen	(26.1)[6]	...	...
17	Nitrate of soda alone=43 lb. nitrogen	35.3[7]	30.6	39.7
4-2	Superphosphate and ammonium-salts=86 lb. N.	35.5[5]	28.3	31.5
10	Mineral manure (without potash), and ammonium-salts=86 lb. N.	49.3	38.1	37.3
9	Complete mineral manure and ammonium-salts=86 lb. N.	54.1	46.8	48.6
13	As Plot 9, and chaffed wheat straw also to 1897 inclusive	62.5[6]		...
11-1	Complete mineral manure, and ammonium-salts=129 lb. N.	65.5	64.6	59.0
11-2	As Plot 11-1, and silicate of soda	72.0	68.0	74.5
16	Complete mineral manure and nitrate of soda=43 lb. N.	48.0[7]	42.4	52.3
14	Complete mineral manure and nitrate of soda=86 lb. N.	59.3[7]	53.4	57.6

1 After the change. Before the change, 42.9 cwt.
2 ,, ,, 49.5 cwt.
3 ,, ,, 30.6 cwt.
4 ,, ,, 35.4 cwt.

5 44 years only (1859-1902).
6 42 years (1856-1897).
7 45 years only (1858-1902).

GRASS FOR HAY.

The experiments upon grass at Rothamsted began in 1856, about 7 acres of the park close to the house being set aside for the purpose. The land has been in grass as long as any recorded history of it exists, for some centuries at least. It is not known that seed has ever been sown, and at the beginning of the experiments the herbage on all the plots was apparently uniform.

The plots, of which there are twenty in all, vary somewhat in size, from

one-half and one-eighth of an acre. Up to 1874, inclusive, the grass was only cut once, the aftermath being fed off by sheep. Since that time there has been no grazing, and the plots are generally cut twice in the year. The grass is made into hay in the usual way, and the whole produce of each plot is then weighed.

1. *Effect of Manures upon the Nature of the Herbage.*

In dealing, however, with the produce of grass-land, which is a mixed herbage consisting of many different species of grasses, leguminous plants, and other orders, it is not sufficient to consider only the gross weight of produce. The various species are differently stimulated by particular manures: even among the grasses themselves, such a difference of habit as a deep or shallow root system will determine to which manure the grass will respond. The aspect of any meadow represents the results of severe competition among the various species represented: the dominant species are those most suited to their environment—*i.e.*, to the amount and nature of the plant-food in the soil, the water-supply, the texture of the soil, and other factors. If any of these factors be altered, as is done in the case of the Rothamsted plots by manuring in different fashions, the original equilibrium between the contending species is disturbed; some species are favoured, and increase at the expense of the others until a new equilibrium is attained, and the general character of the herbage from the botanical point of view is completely altered. It thus becomes important to ascertain the nature of the plants comprising the herbage produced by a given manure, as well as to determine its amount: from time to time, therefore, at Rothamsted a carefully selected fraction of the herbage from each plot has been separated into its constituent species, the relative proportions of which are determined by weighing. As this complete separation involves a great amount of work, a partial separation only is made every year, in which case the herbage is separated into three groups — the grasses, the leguminous plants, and the miscellaneous species respectively.

2. *The Unmanured Plots.*

Two of the plots have remained without manure during the whole of the experiment. They are situated near the extremities of the field, and show a slight but constant difference in crop. Taking the average of the whole period, these unmanured plots have produced rather more than a ton of hay per acre per annum. If we compare the successive ten-year returns, there is no sign of approaching exhaustion or great falling-off in crop from year to year. The impoverishment of these unmanured plots is more to be seen in the character of the herbage than in the gross weight of produce. Weeds of all descriptions occupy the land, and the relative proportion they bear to the grasses and clovers has increased from year to year. A fair proportion of clovers, both red and white, is found on these plots, but the weeds, which amount to 26 per cent, taking the average over the whole period, have of late years constituted nearly one-half of the herbage. The most prominent species among the grasses are the quaking-grass, so generally taken as a sign of poor land, which constituted 20 per cent of the whole herbage in 1903, and sheep's fescue; among leguminous plants the bird's-foot trefoil; and burnet, hawkbit, and black knapweed among the weeds.

Speaking generally, these plots now present the appearance, perhaps in a rather exaggerated degree, of much of the poor pasture and meadow-land in this country, wherever milch cows and wet flocks are habitually grazed and the land occasionally hayed, without anything being restored in the shape of artificial food or manure.

3. *Use of Nitrogenous Manures alone.*

Three of the plots—17, 5, and 1—show the effect of the long-continued use of nitrogenous without any mineral manures. Plot 5 has been receiving 86 lb. of nitrogen as ammonium-salts, Plot 17 half the quantity of nitrogen in the shape of nitrate of soda, and Plot 1 the same half quantity of nitrogen as ammonium-salts, though on this plot dung was applied in each of the first eight years of the experiment. It is very evident that when a nitrogenous manure is

used alone for grass, nitrate of soda is far more effective than the ammonium-salts—*e.g.*, on Plot 17 it has given an average crop of 35 cwt. against 26 cwt. produced by double the quantity of nitrogen in ammonium-salts on Plot 5.

TABLE XVI.—PERCENTAGES OF GRAMINEOUS, LEGUMINOUS, AND MISCELLANEOUS HERBAGE. AVERAGE OF FORTY-SEVEN YEARS (1856-1902, AND 1902 SEPARATELY). ROTHAMSTED. FIRST CROPS.

Plot.	Manures.	Average over 47 years (1856-1902).			Season 1902.		
		Gramineæ.	Leguminosæ.	Miscellaneæ.	Gramineæ.	Leguminosæ.	Miscellaneæ.
		per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
3	Unmanured every year	64.8	8.9	26.3	34.3	7.5	58.2
12	Unmanured every year	64.9	9.0	26.1	38.1	16.1	45.8
2	Unmanured; following farmyard dung for first 8 years	75.5	4.3	20.2	24.4	5.7	69.9
1	Ammonium-salts alone (=43 lb. N.); with farmyard dung for first 8 years	87.8	0.7	11.5	77.6	1.4	21.0
4-1	Superphosphate of lime	68.0	5.8	26.2	54.4	15.4	30.2
8	Mineral manure without potash[1]	70.6	6.8	22.6	28.8	22.1	49.1
7	Complete mineral manure	62.0	23.8	14.2	20.3	55.3	24.4
6	Complete mineral manure as Plot 7; following ammonium-salts alone first 13 years	...	...	...	18.4	61.0	20.6
15	Complete mineral manure as Plot 7; following nitrate of soda alone first 18 years	...	..	...	26.2	63.1	10.7
5	Ammonium-salts alone=86 lb. N.	80.5	0.4	19.1	...	...	...
17	Nitrate of soda alone=43 lb. N.	71.0	1.3	27.7	43.8	3.4	52.9
4-2	Superphosphate and ammonium-salts=86 lb. N.	88.2	0.1	11.7	91.5	(0.01)	8.5
10	Mineral manure (without potash),[1] and ammonium-salts=86 lb. N.	90.7	0.1	9.2	97.6	(0.01)	2.4
9	Complete mineral manure and ammonium-salts=86 lb. N.	88.7	0.4	10.9	91.2	1.3	7.5
13	As Plot 9, and chaffed wheat straw also to 1897 inclusive	92.3	0.3	7.4	98.1	0.6	1.3
11-1	Complete mineral manure and ammonium-salts=129 lb. N.	95.8	0.1	4.1	99.2	0	0.8
11-2	As 11-1, and silicate of soda	97.5	0	2.5	99.5	0	0.5
16	Complete mineral manure and nitrate of soda=43 lb. N.	82.9	5.4	11.7	61.7	12.8	25.5
14	Complete mineral manure and nitrate of soda=86 lb. N.	90.6	1.3	8.1	88.8	3.7	7.5

[1] Including potash first 6 years.

For this superiority of the nitrate of soda two reasons may be traced: being completely soluble it sinks deeply into the soil, and encourages grasses of a deeply rooting habit, which not only obtain more food from the soil, but also are better able to withstand the droughts of spring and early summer. On Plot 17 (nitrate) deep-rooting grasses like meadow foxtail and downy oat grass are prominent, whereas the plots receiving only ammonium-salts are almost wholly occupied

by sheep's fescue and common bent, whose feeding-roots are close to the surface, where the ammonium-salts are caught and retained by the humus in the soil.

The continued use of large applications of ammonium-salts has also had an injurious effect upon the reaction of the soil, since it behaves as an acid, and continually removes carbonate of lime. A creeping surface vegetation tends to accumulate, and decays into a substance resembling peat; at the same time the vegetation shrinks into tufts, between which are bare patches of black soil, showing an acid reaction to litmus paper. So pronounced had this effect become on Plot 5, which received the larger amount of ammonium-salts, that the application has been discontinued since 1897, lest the turf should be entirely killed. Another sign of the sourness caused by the use of ammonium-salts without minerals is seen in the prevalence of sorrel on this plot: it forms nearly 15 per cent of the whole herbage, and it is interesting to note that the only portion of the plot from which the sorrel is absent is a strip that was dressed with chalk in 1883 and 1887. The ill effect of continually manuring with a fertiliser containing only one of the constituents of a complete manure is seen in the very large proportion of weeds on Plot 17 (nitrate of soda alone), where the yield also has declined decade by decade. It is remarkable, however, how well the crop has been maintained, in spite of the fact that nitrate of soda is usually regarded as "exhausting."

4. *Mineral Manures used alone.*

On three of the plots no nitrogenous manures have been applied since the beginning of the experiments. On Plot 7 a complete mineral manure, supplying phosphoric acid, potash, magnesia, and soda, is used; Plot 8 has received the same application, but without potash, since 1861, while Plot 4-1 receives superphosphate only. With the complete minerals a fair crop is grown, averaging over 1½ ton of hay for the first cut alone. The reason that the crop on this plot is maintained, although no nitrogen is supplied in the manure, lies in the free growth of leguminous plants.

It will be seen that, taking the average over the whole period the leguminous plants form 24 per cent of the herbage, and the proportion has increased from year to year. These leguminous plants are not only themselves independent of nitrogen in soil or manure, but by fixing the atmospheric nitrogen and leaving it behind in the residues of their dead roots, they provide a supply of combined nitrogen for the grasses and other plants which cannot of themselves feed on the free gas in the air. The predominant leguminous plant is *Lathyrus pratensis*, but red and white clover are also abundant.

The omission of potash on Plot 8 has caused a very striking difference both in the crop and in the character of the herbage. The average crop has been about one-quarter less over the whole period, and shows a progressive decline in fertility, until at the present time it is little more than half that of Plot 7. The poor results on this plot, as compared with Plot 7, must be put down to its poverty in leguminous herbage, the development of which depends on a free supply of potash. Of late years the proportion of leguminous plants on this plot has amounted to about one-half of that found on Plot 7; the grasses are about the same, the difference being made up by an increased amount of weed.

Plot 4-1, which each year has received superphosphate only, now presents a very impoverished appearance, and is giving no more crop than the unmanured plots. Indeed the aspect of this plot, where the most abundant grass is quaking-grass, and where weeds, chiefly hawkbit, burnet, and plantain, are unusually prominent, would seem to indicate that the land is more exhausted here than on the unmanured plot.

5. *Complete Manures—Nitrogen and Minerals.*

Among the plots which receive both nitrogenous and mineral manures, Plot 9, with a complete mineral manure and ammonium-salts, should be compared with Plot 14, which is exactly similar except that the nitrogen is applied in the form of nitrate of soda, and again with Plot 16, where only half the amount of nitrogen is applied, but again as nitrate of soda. The nitrate of soda gives the heavier yield, the herbage is also more

diversified, and there is not the total absence of leguminous plants which marks the plots receiving ammonium-salts. Two characteristic plants, soft brome grass and beaked parsley (*Anthriscus sylvestris*), are found only on the plots receiving nitrate of soda, the corresponding umbelliferous plant where ammonium-salts are used being the earth-nut (*Conopodium denudatum*).

On Plot 11 the same mineral manures are applied with an extra amount of ammonium-salts, so that the nitrogenous manuring is excessive. As a result, the vegetation consists entirely of tufts of three coarse grasses—meadow foxtail, Yorkshire fog, and tall oat grass. The soil has also become sour and unhealthy; the plant is dying in patches, except on the upper portion of the plot where lime has been applied, and on the half numbered 11-2 where the silicate of soda is used.

The effect of omitting potash from the complete manure is seen on Plot 10, and again on Plot 4-2, where superphosphate and ammonium-salts only are applied. It is noticeable that the grass on all the potash-starved plots is weak in the straw and liable to fungoid attacks.

TABLE XVII.—THE PARK, ROTHAMSTED. (FIRST CROPS ONLY.) PRODUCE PER ACRE.

Plots.	1903.		1904.		1905.		1906.		1907.	
	Limed.	Unlimed.	Limed.	Unlimed.	Limed.	Unlimed.	Limed.	Unlimed.	Limed.	Unlimed.
	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.
3	16.34	10.61	30.20	22.46	18.78	15.79	11.88	12.18	23.08	19.44
7	51.91	49.46	61.83	61.87	47.15	44.34	41.40	34.38	60.02	54.35
9	60.49	50.07	69.76	63.69	52.18	36.87	49.95	39.01	66.81	63.14
11-1	80.84	70.20	88.40	85.42	50.97	24.71	51.62	42.89	58.44	34.89
16	45.68	48.68	52.12	53.34	41.97	46.19	38.47	39.25	47.24	53.56

6. *Changes in the Herbage following changes in Manuring.*

Plot 6 was up to 1868 manured with ammonium-salts alone, like the adjoining Plot 5; the ammonium-salts were then replaced by a complete mineral manure containing potash. The result is seen in the way leguminous plants have gradually invaded the plot, until they now are just as prominent as they are on Plot 7 where mineral manures have been used throughout. The southern half of Plot 5 has also been manured with minerals instead of ammonium-salts since 1898, and the gradual invasion of leguminous plants may now be seen in progress.

On Plot 15 nitrate of soda was applied up to 1875, when a change to a complete mineral manure was made, with the same result of the incoming of the leguminous plants.

7. *Effect of Lime.*

The southern halves of Plots 1 to 4-2, 7 to 11-2, 13, and 16, were dressed with ground quicklime, at the rate of 2000 lb. per acre, in January 1903, and the treatment was repeated in January 1907.

Table XVII. shows the results each year (first crop only) on the limed and unlimed portions of some of the plots.

It will be seen that the lime has produced an increase of crop on the unmanured Plot 3; on 7, which receives minerals only; on 9 and 11-1, which receive a complete manure containing ammonium-salts; but not on Plot 16, where a complete manure is also used, containing nitrate of soda in place of the ammonium-salts. In many cases the benefit of the lime is more marked in the third and fourth crop after its application than in its first.

The greatest increase is to be found on Plots 9 and 11-1, where the soil had become acid through the long use of salts of ammonia, and where there was a considerable accumulation of organic matter; on Plot 16, which receives nitrate of soda, the soil is always slightly alkaline, and the lime produces no beneficial effect. These results confirm the opinion that the value of liming the soil consists in the neutralisation of acids, so

that the organic matter can decay properly, and the liberation of reserves of potash in the soil.

ROOT CROPS.

The Barn Field at Rothamsted has been given up to experiments upon roots since 1843, and no change has been made in the system of manuring the different plots since 1856. At first the field was devoted to white turnips, then swedes, but as it proved impossible to grow these crops year after year upon the same land, mangel-wurzel have occupied the land since 1876, and no difficulty has been experienced in growing successive crops of this root, beyond those due to the bad effect of the repeated use of some of the manures upon the tilth of the soil.

1. *Continuous Growth of Mangel-wurzel.*

The following tables give the nature and amount of the manures applied to each plot, the average crop during the whole period of thirty-one years, and the crop, both root and leaf, of 1907.

TABLE XVIII.—EXPERIMENTS ON MANGEL-WURZEL, BARN FIELD, BEGINNING 1876. QUANTITIES OF MANURES PER ACRE PER ANNUM.

Strip.	Strip Manures.					Nitrogenous Manures running across all the Strips.					
						Series O.	N.	A.	AC.		C.
	Farmyard Manure.	Superphosphate.	Sulphate of Potash.	Sulphate of Magnesia.	Chloride of Soda. (Salt.)	None.	Nitrate of Soda.	Ammonium-salts.[1]	Rape-cake.	Ammonium-salts.[1]	Rape-cake.
	tons.	cwt.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
1	14	...	...	...	...	...	550	400	2000	400	2000
2	14	3·5	500[2]	...	...	...	550	400	2000	400	2000
4	...	3·5	500	200	200	...	550	400	2000	400	2000
5	...	3·5	...	...	...	...	550	400	2000	400	2000
6	...	3·5	500	...	...	...	550	400	2000	400	2000
7[3]	...	3·5	...	200	200	...	550	400	2000	400	2000
8	...	...	...	...	...	...	550	400	2000	400	2000

[1] Equal parts sulphate and muriate ammonia of commerce.
[2] The addition of potash to Plot 2 began in 1895. [3] Commenced in 1903 only.

TABLE XIX.—BARN FIELD, MANGEL-WURZEL. AVERAGE PRODUCE OF ROOTS PER ACRE OVER TWENTY-SEVEN YEARS (1876-1902).

Strip.	Strip Manures.	Cross-dressings.				
		O.	N.	A.	AC.	C.
		None.	Nitrate of Soda.	Ammonium-salts.	Rape-cake and Ammonium-salts.	Rape-cake.
		tons.	tons.	tons.	tons.	tons.
1	Dung only . . .	17.44	24.74	21.73	24.05	23.96
2	Dung, super., potash[1] .	17.95	25.19	22.35	24.91	24.43
4	Complete minerals .	5.36	18.01	14.86	25.49	21.33
5	Superphosphate only .	5.21	15.40	7.66	10.38	11.13
6	Super. and potash . .	4.55	15.38	14.03	22.48	18.63
8	None	3.91	10.24	5.89	9.84	10.00

[1] The addition of potash to Plot 2 only began in 1895.

TABLE XX.—BARN FIELD, MANGEL-WURZEL. PRODUCE OF ROOTS AND LEAVES PER ACRE. SEASON 1907.

Strip.	Strip Manures.	Cross-dressings.				
		O.	N.	A.	AC.	C.
		None.	Nitrate of Soda.	Ammonium-salts.	Rape-cake and Ammonium-salts.	Rape-cake.
		tons.	tons.	tons.	tons.	tons.
1	Dung only	R 26.00	41.42	33.52	34.29	35.02
		L 3.64	4.64	5.27	4.90	5.17
2	Dung, super., potash	R 26.52	42.13	41.68	43.52	40.74
		L 3.33	4.61	6.64	7.08	5.34
4	Complete minerals	R 5.95	32.80	26.68	40.97	33.09
		L 1.09	4.47	3.42	5.25	4.11
5	Superphosphate only	R 6.21	24.62	10.88	11.26	15.43
		L 1.17	3.42	2.86	2.18	2.18
6	Super. and potash	R 5.78	25.05	25.22	35.88	28.15
		L 1.05	3.14	3.44	5.68	2.84
8	None	R 5.15	18.60	9.87	10.90	13.24
		L 1.06	3.84	3.03	2.26	2.40

It will be seen that, considering the amount of manure that is used on many of the plots, the average returns are low, much below the weight a good farmer would expect to get in an average season with his land in good condition for mangolds. It is, however, to be remembered that these are average results from the actual weights removed from the land, with no allowances for blanks caused by insect attacks, drought, &c., and though the manuring appears excessive, the mangold crop grown year after year on the same land takes away a good deal more than does an ordinary rotation. There is no particular evidence that growing this crop continuously on the same land causes any progressive deterioration in the yield; in fact, some of the crops during the last few years have been higher than any during the earlier years of the experiment.

2. *Value of Farmyard Manure for Mangel-wurzel.*

On a first consideration of the results, the most notable thing is the value of farmyard manure in growing mangel-wurzel. This is due not to the plant-food the dung contains, but to its beneficial effect upon the texture of the soil. To secure a good crop of roots with a moderate rainfall on the stiff soil of Rothamsted, the chief difficulty lies in the preparation of a satisfactory seed-bed. In favourable seasons it is possible to obtain good crops on the plots receiving no organic manure, but in ordinary years the bad texture of the soil which results from such treatment, and its tendency to lose water because of the lack of humus, affect both the germination of the seed and the growth of the plant in its early stages. Thus the all-important start of the mangel-wurzel plant is promoted by the use of farmyard manure and, to a less degree, of rape-cake; but once the plant has been established the dung is best supplemented by the addition of some more active source of nitrogen.

Since the farmyard manure is applied every year at Rothamsted at the rate of 14 tons per acre, there is a great accumulation of fertility on the plots which receive it. Notwithstanding the store of nitrogen thus present, in years of abundant growth the crop cannot be supplied with nitrogen rapidly enough by the dung and its residues, so that the yield is considerably increased by the addition of more active fertilisers, especially of nitrate of soda. For example, in 1907 farmyard manure alone gave 26 tons of roots, which was increased to 41 tons by the further addition of nitrate of soda.

During the earlier years of the experiment, the plots numbered 2 received superphosphate in addition to the dung, while Plot 1 had dung only: no increase of crop resulted from the superphosphate. But for the last twelve years Plots 2 have received both superphosphate and

sulphate of potash, and this mixture has given a fair return where ammonium-salts or rape-cake is used as an additional source of nitrogen. This increase must be attributed to the sulphate of potash, since the superphosphate alone made no difference to the yield of the dunged plots. It is somewhat remarkable that sulphate of potash should still be effective on a strong soil naturally rich in potash, and on plots to which farmyard manure in excess has been applied yearly for more than half a century, but the mangel-wurzel is, above all other crops, a potash-loving plant.

3. *Effect of Nitrogenous Manures on Mangel-wurzel.*

The experiments with artificial manures show the great dependence of the mangel-wurzel crop upon an abundant supply of nitrogen in the manure: up to as much as 180 lb. of nitrogen per acre the yield increases with each addition of nitrogenous manure; beyond that point there is no increase in the crop from further nitrogen, and in practice probably 100 lb. of nitrogen per acre would represent the paying limit.

The experiments further bring out the fact that, as a nitrogenous manure for mangel-wurzel, nitrate of soda is much more effective than sulphate of ammonia containing the same amount of nitrogen. For this superiority there are two reasons: firstly, the soda base of the nitrate of soda renders more soluble the potash compounds in the soil or in the other manures used, thus economising the large amounts of potash the mangel-wurzel crop always requires. This is well seen on comparing the yields of Plots 1 and 2, Table XIX. When ammonium-salts or rape-cake are added to the dung, as on Plots 1 and 2, A, AC, and C, there are much better crops on Plot 2 with sulphate of potash than on Plot 1 without sulphate of potash. But Plot 2 N gives practically the same crop as Plot 1 N. In this case the nitrogenous manure is nitrate of soda, and this can set free so much potash from the dung on Plot 1 that the use of sulphate of potash on Plot 2 produces no increase of crop.

Secondly, the deep-rooting habit induced by nitrate of soda gives the plant a better supply of water through the dry periods, and causes it to keep growing later in the autumn, thus increasing the weight of the crop. The leaves of the plants on the plots receiving ammonium-salts always turn yellow and begin to die off long before any change is to be seen on the plots receiving nitrate of soda.

4. *Effect of Potash Salts upon Mangel-wurzel.*

But the most striking fact which is demonstrated on these plots as to the nutrition of the mangel-wurzel is its dependence upon an ample supply of potash. We know that potash is necessary to the process in the plant by which carbohydrates like sugar and starch are manufactured out of the carbonic acid of the air, and the mangel-wurzel is essentially a sugar-making plant, since more than three-quarters of the dry matter in the root consists of cane-sugar; hence the crop must have plenty of potash at its disposal. If the yield of Plots 4 and 6, especially in series A, C, or AC, be compared with the yield of the corresponding Plots 5 (no potash), the magnitude of the effect produced by potash will be plain. The following table will serve as an example from a particular year:—

TABLE XXI.—PRODUCE OF MANGEL-WURZEL, ROTHAMSTED, 1900.

Plot.	Manure.	Leaf per acre.	Roots per acre.	Sugar per acre.
		tons.	tons.	tons.
5 A	Sulphate of ammonia, superphosphate . . .	2.95	12.00	0.80
6 A	" " super., and sulphate of potash .	3.60	28.20	2.47

The only difference in the manuring of the two plots lay in the sulphate of potash applied to 6 A. This hardly affected the amount of leaf produced,

but it increased the roots from 12 to 28 tons, and the sugar contained in these roots from 0.8 of a ton to 2.47 tons. Of course, Plot 5 A, by long cropping with nitrogenous and phosphatic manures without potash, has been impoverished as regards its potash in a way that would rarely or never occur in ordinary farming. Still, the example is instructive as showing how essential a part potash must be of a mangel-wurzel manure.

5. *Proportion of Manure Recovered in Crop.*

As the nitrogen in the crop is determined each year, it becomes possible to trace the return from each of the nitrogenous manures with which the mangel-wurzel are grown, so as to estimate the efficiency of the manure by the percentage recovered in the crop.

From Table XXII. it will be seen that when the nitrogenous manures were used in conjunction with phosphates and potash, the recovery ranged from 78 per cent with nitrate of soda down to 56 per cent with a mixture of rape-cake and ammonium-salts. This latter mixture contained, however, more than twice the amount of nitrogen supplied by the nitrate of soda, and the proportion recovered in the crop is always less with a heavy than with a light manuring, as is very evident from the second part of the table, in which the nitrogenous manures are used in conjunction with dung.

TABLE XXII.—MANGEL-WURZEL.—NITROGEN RECOVERED IN ROOTS FOR 100 IN MANURE.

Series.	Cross-dressings.	Average produce per acre of Roots.	Nitrogen.			
			Per cent in fresh Roots.	Per acre per annum in Roots.	Supplied in Manure per acre per annum.	Recovered in Roots for 100 in Manure.
Plots 4.—Superphosphate, sulphates of potash and magnesia, and common salt.						
		tons.	per cent.	lb.	lb.	per cent.
N	Nitrate of soda . . .	17.95	0.164	67.2	86	78.1
A	Ammonium-salts . . .	15.12	0.145	49.3	86	57.3
AC	Ammonium-salts & rape-cake	24.91	0.184	103.0	184	56.0
C	Rape-cake	20.95	0.148	69.4	98	70.9
Plots 1.—Farmyard dung, 14 tons.						
0	None	17.44	0.162	63.3	200	31.6
N	Nitrate of soda . . .	24.74	0.209	115.8	286	40.5
A	Ammonium-salts . . .	21.73	0.217	105.6	286	36.9
AC	Ammonium-salts & rape-cake	24.05	0.241	129.8	384	33.8
C	Rape-cake	23.96	0.207	111.1	298	37.3

On the plot receiving farmyard manure alone, less than one-third of the nitrogen supplied is ever recovered in the crop, and the recovery of the other nitrogenous manures added to the dung ranges from 40 per cent with nitrate of soda down to 37 per cent with sulphate of ammonia or rape-cake.

6. *Effect of Manures upon the Tilth of the Soil.*

Another secondary result of the manuring that is very manifest on these mangel-wurzel plots is the deleterious action of certain artificial fertilisers upon the tilth of the land. The soil becomes excessively sticky and tenacious after wet weather; on drying it sets very hard, with a tough, glazed surface that cannot be pierced by a young, freshly germinated seedling. These effects are seen where exclusively mineral manures are applied without dung or rape-cake; they are at their worst on the plots receiving nitrate of soda and sulphate of potash. Sulphate of ammonia and superphosphate leave the land in a friable state when dry, but where both nitrate of soda and

sulphate of potash are applied the land becomes almost unworkable, and the plant is always defective and full of gaps,—in one or two seasons, indeed, it has failed entirely on this plot. The effect has been traced to the nitrate of soda. As the plant grows it takes up an excess of the nitric acid, leaving behind the soda as a carbonate. Like other soluble alkalies, the carbonate of soda causes the clay to divide into its finest particles: all the clay properties are intensified just as if the soil had been puddled in a wet condition. Sulphate of potash under certain conditions also gives rise to a little free alkali, and it is this small amount of alkali from the nitrate of soda and the sulphate of potash, alkali which can actually be extracted from the soil, that has destroyed the tilth.

7. *Manures and the Incidence of Disease.*

Another secondary result of manuring that is always to be seen on these mangel-wurzel plots is the variation in the susceptibility of the plant to fungoid disease induced by the different fertilisers. The leaves of the mangel-wurzel growing on the plots receiving an excessive amount of nitrogen are always attacked towards the end of the season by a leaf-spot fungus, *Uromyces betæ*, until in bad years the leaf is entirely shrivelled and burnt up before the crop is ready to lift.

The attack is chiefly to be seen on the high nitrogen plots, but even there it is kept off by the use of potash manures; so that although all the plots are close to one another, and equally open to infection, it is only the plots receiving an excessive amount of nitrogen or without potash which show any disease. The same thing is true of other plants and fungi—that an excess of nitrogen predisposes the plant to an attack, whereas potash strengthens it against the attack.

The *general conclusions* derived from a study of the mangel-wurzel field at Rothamsted — that a mangel-wurzel manure should be highly nitrogenous, nitrate of soda upon a basis of farmyard manure being the best combination, and that it should also contain an abundance of potash—does not, however, hold for all root crops. Swedes, cabbage, and other cruciferous crops are very specially dependent upon phosphoric acid, and swedes at least do not require much nitrogenous manure.

OTHER EXPERIMENTS AT ROTHAMSTED.

Space does not allow us to give an account of the experiments upon crops grown in rotation in Agdell Field, and upon the leguminous crops in Hoos Field or the experiments in Little Hoos Field, designed to estimate the value of the residues left by manures after one, two, and three crops have been grown with them.

For such accounts the original papers issued from Rothamsted should be consulted (they numbered 205 down to the end of 1907, and are to be found in the *Philosophical Transactions and Proceedings of the Royal Society*, the *Transactions of the Chemical Society*, the *Journal of the Royal Agricultural Society*, &c., &c.); or the summary contained in the *Book of the Rothamsted Experiments*, published by J. Murray in 1905; or the lectures delivered in America by Sir J. H. Gilbert, published by the Highland and Agricultural Society in 1895.

The same sources must be consulted for accounts of the other scientific work on agricultural subjects that has gone on at Rothamsted during the last sixty years. The feeding experiments, though they have been largely superseded by the more refined methods of investigation perfected in Germany, established some of the fundamental facts in the nutrition of our domestic animals, and in one direction—the composition of the carcass of the whole animal—still form the only basis of our knowledge. Other investigations have dealt with the composition of the soil and the changes induced in it by the action of manures, with the bacteria causing nitrification, nitrogen fixation, and other actions beneficial or noxious to plants, with the composition of the plants themselves as affected by manuring and season. It is hardly too much to say that there is no branch of the chemistry of the growing plant which does not find elucidation and experimental illustration among the results that have been accumulated at the Rothamsted Experimental Station.

HIGHLAND AND AGRICULTURAL SOCIETY'S EXPERIMENTS.

At one time or another the Highland and Agricultural Society of Scotland has carried out a large number of useful experiments upon the manuring of crops, the feeding of live stock, and other matters relating to agriculture. The Society's most extensive schemes of experiments in manuring were those inaugurated in the year 1878 under the care of the late Dr A. P. Aitken, who was chemist to the Society from the year 1877 till the time of his death in 1904. The notes subjoined here contain the essence of Dr Aitken's official reports on these experiments.

Object of the Experiments.—The object of the experiments begun in 1878 was to test the accuracy of many views then prevalent regarding the efficacy of the various light manures in use among farmers, to discover what was the agricultural or crop-producing values of these substances, and to see how far these values corresponded with the prices at which the substances were being sold in the market.

It was believed by many advanced farmers that large sums of money were annually being spent in the purchase of manurial substances whose efficacy as manures was entirely out of harmony with their market prices, and that nothing short of an extended series of experiments, performed upon an agricultural scale over two rotations, would be capable of uprooting old prejudices, and of enlightening farmers regarding the true value of the substances in which so much of their capital was being invested. It was believed that such a series of experiments would not only determine, in a practical and reliable manner, what was the real value of manures, but would also supply much-needed information regarding the special utility of the various ingredients of manures, the forms in which they could be most profitably employed, and the most rational and economical methods in which to apply them.

The Stations.—For this purpose the Society rented two fields,—one at Harelaw, in East Lothian, and one at Pumpherston, in West Lothian. At each station 10 acres were set apart and divided into forty plots of one rood each. The soil of the former, a rich deep loam near the sea-level, in a dry early district; and that of the latter, a thin clayey loam, resting on the till or boulder clay, a somewhat wet and late district, 400 feet above the level of the sea.

No dung was applied to the stations during the course of the experiments, nor for four years previous to their commencement.

Manures tried.—The three classes of manures under experiment were phosphates, nitrogenous matters, and potash salts of the following kinds:—

Phosphatic Manures.

Carolina land phosphate.	Phosphatic guano.
Canadian apatite.	Coprolites.
Curaçoa phosphate.	Bones, in various forms.
Aruba phosphate, &c.	Bone-ash.

These were applied in a finely ground state, and also after having been dissolved in sulphuric acid.

Nitrogenous Manures.

Soluble	Nitrate of soda.	
	Sulphate of ammonia.	
Insoluble	Meat-meal	of animal origin.
	Dried blood	
	Horn-dust	
	Keronikon	
	Shoddy or wool-waste	
	Rape-cake dust	of vegetable origin.
	Cotton-cake dust	
Guanos, &c.	Peruvian guano.	
	Ichaboe guano.	
	Fish-manure.	
	Frey Bentos manure.	

Potash Manures.

Sulphate of potash.
Muriate of potash.

These manures were so applied that each plot received the same quantity of *phosphoric acid, of nitrogen, and of potash*, whatever might be the form in which these were applied, and irrespective of the gross weights of the substances, or of their market prices.

Cropping.—The cropping consisted of a four-course rotation of turnips, barley, beans, and oats.

Manures for Turnips and Beans.—When the crop was turnips or beans,

the manures applied to these plots contained—

	lb. per acre.
Phosphoric acid . .	160
Nitrogen . . .	40
Potash	120

Manures for Cereals. — When the crop was barley or oats, the manure contained—

	lb. per acre.
Phosphoric acid . .	80
Nitrogen . . .	40
Potash	60

The plots on which the various *phosphatic manures* were tested, received, in addition, their proper quantity of potash in the form of a mixture of muriate and sulphate, and their nitrogen in the form of nitrate of soda.

The plots on which the various *nitrogenous manures* were tested, received, in addition, their proper quantity of phosphoric acid in the form of superphosphate, and their potash as mixed sulphate and muriate.

The plots on which the two *potash salts* were tested, received their proper quantity of phosphoric acid as superphosphate, and their nitrogen as nitrate of soda.

The great majority of the plots on the stations were thus fully manured; and in so far as the essential ingredients—phosphoric acid, ammonia, and potash—were concerned, they all fared alike. It was only the outward and accidental form and fashion of these substances that differed.

In order to form a starting-point or basis of comparison for the whole station, three plots received no manure whatever.

In order to measure the specific effects of each of the three essential ingredients, three plots received one of each and nothing else, while from other three plots each of the three essential ingredients respectively was withheld.

In addition to the two series of experiments on the stations, there were annually carried out a selected number of experiments on farms in various parts of the country to test the accuracy of the results obtained, and to acquire additional information regarding the action of manures when applied to different soils and under different climatic conditions.

Full reports of the experiments were published annually in the Society's *Transactions*, and the following is a general statement of the chief results obtained and observations made.

I. Results with Phosphatic Manures.

Produce of Dry Matter from Pumpherston.—During the eight years comprised in the two rotations, the total amount of dry vegetable matter per acre, in the form of roots, grain, and straw, removed from the plots to which *complete manures* had been regularly applied on that section of the station at Pumpherston devoted to the study of phosphatic manures was as follows:—

	Tons of Dry Matter, per acre.	
	Undissolved.	Dissolved.
Bone-ash . .	12.69	12.66
Ground coprolites	11.80	13.22
Bone-meal . .	11.32	13.80
Phosphatic guano	12.47	14.11
Ground mineral phosphates . .	11.66	14.16
Average .	11.99	13.59

Conclusions. — The facts apparent from a mere glance at these figures are, that—

Soluble phosphates have produced about 13 per cent more actual fodder than insoluble phosphates.

Bone-meal, which is one of the dearest of the undissolved phosphates, has given the smallest return.

Dissolved mineral phosphate, which is just ordinary superphosphate, and made from the cheapest material, has given the largest return.

Among the insoluble phosphates, *phosphatic guano* and *bone-ash* are best.

Over a series of eight years, the amount of fodder raised by the application of different kinds of insoluble phosphates are not very different.

The following facts, although not apparent from a mere scrutiny of these figures, were attested from year to year during the course of the experiments:—

Insoluble Phosphates.—These vary in their efficacy far more than soluble phosphates. They are more dependent on moisture for their activity, and dur-

ing dry seasons they are of very little use. Even during wet seasons they were found to be very capricious in their action. The phosphate which was the best one year might be the worst the next year.

Fineness of Grinding.—This uncertainty was found to be caused by the different *degrees of fineness* to which they happened to be ground. The finer they were ground, the more effective they were as manures.

A series of experiments made in 1886, on four plots of Pumpherston and on four Lowland farms, with the same mineral phosphate, in two slightly different degrees of fineness, showed uniformly a difference of about 11 per cent in favour of the more finely ground phosphate. The whole question of the efficacy of ground phosphates has been shown to turn on the point of the fineness to which they are ground.

Phosphatic Guano.—The reason why phosphatic guano is so effective a form of insoluble phosphate is presumably because it consists in great measure of very finely divided matter, and also because it contains from 5 to 10 per cent of precipitated or "reverted" phosphate which is in an infinitely fine state of division.

Bone-meal.—The reason why bone-meal is slowest in its action, is probably because it consists in large measure of very coarse particles.

Judged by the standard of fineness of division alone, bone-meal, which was enormously coarser than the other phosphates, should not have produced nearly so much vegetable matter. Its efficacy must therefore depend on other circumstances—notably its power of rotting in the soil, and of accumulating a store of phosphate, in no very long time becoming available as plant-food.

Soluble Phosphates.—Just as the undissolved phosphates differed from year to year in their fineness of grinding, so the dissolved phosphates differed from year to year in the fineness of their manufacture, or in their state of aggregation due to dampness, or the time during which they were kept in bags before being applied. Dissolved manures are liable to cohere into lumps from various causes, and the most careful riddling cannot restore the fine condition of a manure that has become lumpy.

Fine Powdery Condition essential.—Attention was early drawn to this circumstance during the course of the experiments, and observations made indicated that the efficacy of dissolved manures depends largely upon the more or less *powdery condition* in which they are applied.

Insoluble Phosphates for Mossy Land, &c.—A large number of experiments to determine the relative utility of soluble and insoluble phosphates were made on farms differing widely in their soil and climate, and it was found that insoluble phosphates produced their best results upon mossy land, and soils rich in organic matter in wet districts. In such circumstances they were a more economical manure than superphosphate.

Bones and Fineness of Grinding.—An extended series of experiments carried out on the stations, and on other farms, to test the relative manurial value of bone-meal of different degrees of fineness, showed that the finer ground bone-meals gave the best results during the season in which they were applied, and also during succeeding seasons where their after-effects were observed.

II. Nitrogenous Manures.

Produce of Dry Matter at Pumpherston.—The following are the amounts of dry vegetable matter removed from the plots at Pumpherston that were set apart to determine the relative efficacy of nitrogenous manures during the two rotations. The manures contained in each case the same amount of nitrogen, and there was given along with it a definite uniform amount of superphosphate and potash salts.

	Tons per acre.
Nitrate of soda . . .	12.22
Sulphate of ammonia . .	11.62
Horn-dust, shoddy, &c.	9.28
Dried blood . . .	10.38
Rape-cake dust . . .	10.96

As in the case of phosphates, so also in the case of nitrogenous manures, the most soluble substances produced the largest return.

Nitrate of Soda.—This is the most active and efficient of all the nitrogenous

manures, and its action has been studied under a variety of conditions at the stations, and on other soils of very different character.

Its chief peculiarity is that it acts almost immediately on the crop, and produces a marked effect whether ploughed in with the seed or applied as a top-dressing during the growth of the crop.

When applied to land in good condition, or when it forms part of a complete manure, it causes the crop to braird vigorously, and is sometimes the saving of a crop whose youth is precarious. It is especially valuable in seasons of drought, as it enables the young plant to root rapidly and become less dependent on surface-moisture.

When applied to cereals it causes a more abundant growth of straw than any other manure. When applied with the seed or to the young braird, it not only increases the bulk of the crop, but it hastens its development and causes it to ripen sooner. If applied at a later period, it causes the plant to grow too much to stem and leaf, and it unduly prolongs the period of growth. When applied late as a top-dressing to cereals, it causes a disproportionate growth of straw, retards the period of ripening, and favours the production of light grain.

When applied to a thin sharp soil during a wet season its effect is transient, showing that much of it has been washed down through the soil and out of reach of the roots of the crop.

When applied too liberally on good land, it causes a rapid growth of ill-matured vegetable matter, and produces a crop which is too abundant, unable to ripen, of poor feeding value, and liable to accidents.

When applied to plants grown for their seed, nitrate of soda must be used more sparingly; for increase of stem or straw, if overdone, is secured at the expense of the seed, both in quantity and quality.

It may therefore be used with greater impunity to crops which are grown for the sake of their stem and leaf—chiefly and notably to grass of one or two years' duration.

When applied liberally to grass, it increases the growth of the grasses proper, but diminishes the amount of clover and other leguminous plants; therefore, when a good crop of clover is desired, nitrate should be used very sparingly.

Sulphate of Ammonia.—Sulphate of ammonia is slower in its action than nitrate of soda. It is therefore to be preferred as a nitrogenous manure for crops which have a prolonged period of growth. When applied as a top-dressing to cereals, it retards the time of ripening. A similar effect is produced when applied with the seed in dry districts or during seasons of drought. It does not fail to benefit the crop even upon thin soils and during wet seasons. It is therefore more appropriate than nitrate of soda for application in these circumstances.

Sulphate of ammonia can do little for the germinating seed in dry weather, as it is not in an immediately available form. Even after rain comes, it is some time before the sulphate of ammonia comes into action.

Sulphate of ammonia has been found to check the growth of clover more effectively than nitrate of soda if applied in excess, but in moderate quantity it is an excellent manure for old grass. It is not suitable for application to leguminous crops, which are intolerant of strong nitrogenous manures, especially after the first period of their growth.

Insoluble Nitrogenous Manures.

Insoluble nitrogenous manures are substances containing albuminoid matter. They are very suitable for wet districts, but none of them can be considered a manure until it is finely ground, or rotted, or dissolved.

Rape-cake Dust.—Among the insoluble nitrogenous manures rape-cake dust has produced the greatest amount of vegetable matter. It is very probable that this is due in some measure to the large amount of carbonaceous organic matter contained in it. It was also noticed that the plot to which this manure was applied was singularly free from disease, and that the texture of the soil improved under its application.

Dried Blood, Horn-dust, &c.—Dried blood was found to be a good manure for roots, especially when applied early, but too slow in its action for cereals.

The same remark applies to *horn-dust*

and *keronikon*, which should be applied long before sowing. *Shoddy* was tried on only one occasion, and was found quite inoperative.

All these insoluble nitrogenous matters become, when dissolved in sulphuric acid, good quickly acting manures.

III. Potash Manures.

Potash salts are chiefly important on land that has not been dunged. On dunged land they frequently fail to produce any marked effect.

Sulphate and *muriate* of potash are nearly equal in their action. They are most effective when applied some months before sowing. The crops to which they are most beneficially applied are beans, clover, and leguminous crops generally.

When applied to cereals, they increase the amount of grain to some extent, and they make the straw more elastic and less liable to lodge.

Manuring Turnips.

The results obtained in the experiments on the manuring of turnips were interesting and suggestive, but in some respects they have not been confirmed by more recent investigations.

In reference to his observations of the general effects of the different manures on turnips, Dr Aitken stated that an excess of potash manures was found to decrease the quantity of roots, and might even injure the crop. He considered that it is scarcely possible to overdo the application of phosphates to turnips, so far as the health and feeding quality of the roots are concerned; but too liberal an application of nitrogenous manure unduly increases the tops and retards the ripening of the bulbs, and also increases their liability to disease.

Dr Aitken stated that the nitrogenous matter in turnips is partly of a nutritive and partly of a non-nutritive kind. The former consists of albuminoid matter. The ratio of nutritive to non-nutritive nitrogenous matter varies extraordinarily in different turnips, and under different circumstances of weather and manuring.

Forced Turnips of Bad Quality.—Bulbs grown very rapidly, whether from excess of moisture or too liberal application of soluble nitrogenous manure, have a smaller proportion of their nitrogenous matter in the form of albumen.

Manures which unduly force the growth of turnips may increase the quantity of the crop; but the increase of quantity is got at the expense of quality, and the deterioration of quality is mainly expressed in the large percentage of water and the small percentage of albumen in the bulbs.

Manures for Rich Crops of Turnips.—In order to grow a large and at the same time a healthy and nutritious crop of turnips, such a system of manuring or treatment of the soil, by feeding or otherwise, should be practised as will result in the general enriching and raising of the condition of the land, so that the crop may grow naturally and gradually to maturity.

For that purpose a larger application of slowly acting manures, of which bone-meal may be taken as the type, is much better suited than smaller applications of the more quickly acting kind.

A certain amount of quickly acting manure is very beneficial to the crop, especially in its youth, but the great bulk of the nourishment which the crop requires should be of the slowly rotting or dissolving kind, as uniformly distributed through the soil as possible.

Manures for the Barley Crop.

The relative importance to the barley crop of the three manural ingredients may be seen from a comparison of the results obtained on the plots manured as under for five years:—

No. of Plot.	Grain per acre. lb.
22. Potash	875
12. Phosphate (bone-ash)	1175
17. Phosphate and potash	1256
18. Nitrate	1287
21. Nitrate and phosphate	1706
11. Nitrate and potash	1814
13. Nitrate, potash, and phosphate	2596

Manures applied to the barley crop affect, in the first place, the quantity per acre both in grain and straw; in the second place, and to a much less extent, they affect the quality of both grain and straw, and they materially affect the time of ripening.

Nitrogenous Manure for Barley.—The most important constituent of a manure for the barley crop is nitrogen.

In ordinary circumstances, it is the quantity of nitrogen in the manure or in the soil which determines the bulk of the crop.

In an ordinary rotation of cropping, in which barley succeeds turnips, the *phosphate and potash* required by the crop are relatively abundant in the soil, and a good crop can be obtained if only some nitrogenous manure is applied in sufficient quantity to enable the plant to take up its mineral food.

The kinds of nitrogenous manure most suitable for barley are those which are soluble and rapid in their action, such as sulphate of ammonia and nitrate of soda. *Sulphate of ammonia*, if applied as a top-dressing, and *nitrate of soda*, if so applied, much later than three weeks after the date of sowing, may increase the quantity of the crop both in grain and straw, but the quality of the grain, as indicated by the weight per bushel, will be lowered, and the time of ripening will be retarded.

A difference of three weeks in the time of ripening occurred among the experimental crops. The earliest were those which were manured with soluble phosphate, and whose nitrogenous manure was nitrate of soda applied with the seed. The latest were those which received no nitrogenous manure, an overdose of it, or too late a top-dressing.

Slowly acting nitrogenous manures are of no use to the barley crop, unless applied some months before the time of sowing.

A deficiency in the amount of nitrogenous manure applied to barley not only diminished the total amount of the crop, but it also diminished the percentage of albuminoid matter contained in the grain.

Barley, top-dressed with nitrate of soda, contained somewhat more albuminoid matter than that which had the nitrate applied with the seed.

The amount of albuminoid matter varied from 8½ to 11½ per cent. The former amount was contained in barley, from whose manure all nitrogenous matter was withheld, and the latter from barley top-dressed with nitrate.

Phosphatic Manures for Barley.—*Phosphatic manures* are next in order of importance for barley. The more speedy their action the better; therefore *superphosphate* is the most reliable form of phosphate.

The plots to which soluble phosphates were applied came to maturity ten days before those with insoluble phosphates.

Potash for Barley.—Potash manures somewhat increased the quantity of grain on the station where no dung was applied, and they strengthened the straw. But it was noticed that the grain was somewhat darker in colour than that to which no potash was applied.

Manures for Oats.

The manures required for oats are quick-acting manures, to enable the crop to get a good hold of the soil before the nourishment contained in the seed is exhausted.

For this purpose superphosphate and nitrate of soda are peculiarly applicable.

Sulphate of ammonia, although a soluble manure, did not come into operation in time for the wants of the young plant during the dry season of 1885, and the crop which received that manure was a signal failure at both stations.

Potash manures, especially muriate of potash, had a very beneficial effect upon the oat crop, and considerably increased the yield of grain, and in a less degree the amount of straw.

The *general conclusions* to be drawn from the experiments with the oat crop are, that the treatment of the land should be such as to accumulate organic matter in it, to prevent too great a loss of moisture, and to provide the young plant with manures that come rapidly into operation.

When the young plant has safely passed the critical period of its growth it roots deeply, and lays hold of the moisture and nourishment contained in the subsoil.

Manures for the Bean Crop.

The usual practice in bean-growing districts is to apply dung to the bean break, and the opinion prevails that beans cannot be successfully grown without dung. But the experiments at Pumpherston station show that a full crop of beans may be grown with artificial manures upon land that has not been dunged for ten years.

The relative importance to the bean crop of the three chief constituents of a manure may be seen by comparing the produce of eight plots manured as follows for six years:—

No. of Plot.	Kind of Manure.	Bushels Dressed Grain per acre.
27.	No manure	2½
12.	Phosphate (bone-ash)	5⅙
18.	Nitrate	6¼
21.	Phosphate and nitrate	5⅓
22.	Potash	26½
17.	Potash and phosphate	42⅓
10.	Potash, phosphate, and nitrate	45½
38.	Potash, phosphate, nitrate, and gypsum	51

The characteristic ingredient of a bean manure is potash.

Without potash in the manure, the other two ingredients are of very little use, unless, indeed, the land be very rich in potash.

Potash salts alone may be a sufficient manure on land in good condition, and may even produce a fair crop on land that is in poor condition.

Phosphate, when applied along with potash salts, or when applied to land rich in potash, has a marked effect upon the crop.

Nitrogenous manures, even when of the most favourable kind, have very little influence in increasing the bean crop.

Lime, in the form of gypsum (or sulphate of lime), has a beneficial effect upon the crop.

Dissolved phosphate acts far more powerfully on the bean crop than ordinary ground phosphate.

Phosphatic guano was more effective than ground mineral phosphate, presumably for the reason that a small proportion of it was in an easily dissolved form.

The nitrogenous manures that are most beneficial to the bean crop are those whose action is rapid and soon over. In this respect nitrates are preferable to all other nitrogenous manures.

Nitrogenous manures should either be applied in very small quantity or altogether withheld from the bean crop.

Nitrogenous manures that come into operation after the crop has made some growth have an injurious effect. Even sulphate of ammonia is too slow in its action, and retards the growth of the crop.

Nitrogenous manures should not be applied as a top-dressing to the bean crop.

Peruvian and other nitrogenous guanos are among the worst manures for the bean crop. They contain too much nitrogen and too little potash.

The muriate of potash has proved a more effective manure than the sulphate.

The beneficial effect of gypsum is to be ascribed, not to the sulphuric acid it contains, but to the lime, which, in combination with sulphuric acid, is a soluble manure, and has the power of liberating potash in the soil.

The general results of the experiments with different manures on the bean crop inform us that the bases potash and lime are the substances most required by the crop.

For land dunged in autumn—or for land in good condition—it would seem from the experiments at Pumpherston that the application of superphosphate, muriate of potash, and sulphate of lime, in equal parts, would be a very appropriate manure for the bean crop.

The composition of beans is very uniform whatever be the nature of the manures applied. It is the *quantity* of the crop, and not the *quality* of it, that is affected by the application of manures.

Lessons from Incomplete Manure Experiments.

The following are the amounts of dry vegetable matter yielded during eight years by those plots at Pumpherston from whose manures one or more of the three constituents—nitrogen, phosphoric acid, and potash—were withheld:—

	Tons per acre.
Nitrate and potash (no phosphate)	9.78
Nitrate and phosphate (no potash)	8.97
Potash and phosphate (no nitrogen)	7.65
Nitrate of soda alone	8.68
Bone-ash alone	6.50
Potash salts alone	5.35
Unmanured	5.40

From these figures it is evident that the manurial constituent most required for the production of the crops grown was *nitrogenous matter*, in the next place *phosphates*, and in the next *potash*.

Potash alone.—The plot to which potash salts alone were applied gave

scarcely as much produce as the unmanured plot.

This plot went steadily from bad to worse, and was latterly the worst on the station, showing that the accumulation of potash was hurtful to most of the crops grown there.

There was one exceptional year, 1884, when the crop was beans, and then for the first time it threw up a crop five times as abundant as the neighbouring plot, to which no potash had been applied.

An Experiment for Farmers.—An experiment of the above kind—in which, along with a completely manured plot, there are arranged side by side a series of plots from which in turn one of the essential ingredients of a complete manure is withheld—forms a most instructive lesson for farmers, and should be applied by them to all the fields on their farm. It serves to show what is the ingredient in the soil or in the manure that is most deficient for the production of a crop, and thus guides the farmer in the selection of the light manures that are most appropriate for his purposes.

Manures for different Crops.

A review of the manurial requirements of a rotation of crops, consisting of turnips, barley, beans, and oats, shows that while the three great constituents of a manure—nitrogen, phosphoric acid, and potash—are all required in order to raise full crops and to maintain the fertility of the soil, the predominance which should be given to one or other of these constituents varies with the crop. The predominant constituent is—for

Turnips—Phosphoric acid.
Barley and oats—Nitrogen.
Beans—Potash.

Forms of Manures for Turnips.—For turnips the phosphates should be applied either in a soluble form or in a state of very fine division—in the case of ground phosphates, they should be at least so finely ground as to pass through a sieve of 120 wires to the linear inch,—or they should be of a kind that rapidly rot in the soil (such as bone-meal), and at the same time so finely ground as to permit of their being rotted in great measure during the period of the crop's growth. The nitrogenous manure should be partly of a quick-acting and partly of a slow-acting kind, so as to be of service to the crop during the whole period of its growth.

Forms of Manure for Cereals.—For cereals the nitrogenous manure should be very rapid in its action, so as not to retard the ripening of the crop. If applied as a top-dressing, it should consist of nitrate. The phosphate cannot be too rapid, and on that account superphosphate is to be preferred to any other form of phosphate.

The importance of potash in a cereal manure will depend on whether grass and clover seeds are sown with the crop. If that is the case, potash salts take the second place, as the presence of potash in the manure is of importance for the nourishment of clover.

Forms of Manure for Beans.—For the bean crop, the form of potash salt that is most suitable is the muriate of potash. Superphosphate is preferable to other forms of phosphate, probably on account of the large amount of sulphate of lime contained in that manure; but if sulphate of lime is applied to the crop, any other good phosphatic manure may form part of the mixture. The only kind of nitrogenous manure that is to be recommended for this crop is a soluble one, and that in small quantity, applied with the seed.

Dung for Turnips, Cereals, and Beans.—When farmyard manure is used for the turnip crop, potash salts should not be applied to it, and any nitrogenous manure added should be soluble.

The need which cereal crops have of nitrogen points strongly to the conclusion that a part of the dung should be withheld from the root crop and applied to the white crop; and this is all the more to be recommended, as it is evident that a considerable loss of the nitrogen of the dung is inevitable when a heavy dunging is applied to the fallow break.

If dung is to be used for beans, it should be applied to the stubble, rather than put in with the seed.

Organic Matter.

While it has been stated that on ordinary soils the three constituents—phos-

phoric acid, nitrogen, and potash — are sufficient to form what is known as a complete manure, and that a manure containing two of these substances, or, it may happen, only one of them, is a sufficient manure to apply to certain crops in certain circumstances, it is of the utmost importance here to observe that, nevertheless, it must not be supposed that, in the manipulation of these three constituents, in reference to the crops they are producing, lies the whole question of manuring.

Consider Soil as well as Manure and Crop. — The rapidity with which light manures act upon the crops to which they are applied has tended to restrict our view too much to the two factors —manure and crop — and has caused us to think less of the *soil* than our forefathers did.

Before the days of light manures—a time comparatively recent — when the wants of a crop for phosphates, nitrates, and potash were unknown, farmers fixed their attention upon the soil, and used every means to raise its general fertility —to put it into what is called high "condition,"—and this they did by the use of heavy manures containing a large amount of organic matter.

Function of Organic Matter. — It has since been discovered that plants can grow to perfection without organic matter, but the circumstances in which that is possible for crops are not those which prevail in ordinary farming and in this climate.

It is to the organic matter in the soil that are due many of the changes going on there that are beneficial to the roots of plants. The warmth and moisture of the soil are increased by the organic matter in it, and the acids formed by its decay have an important part to play in dissolving the mineral matter, which forms the food of plants. It is indeed the key to the treasures of the soil. But in the ordinary operations of agriculture —in the constant disturbing and working of the ground—organic matter is rapidly destroyed, so that if farmyard manure and organic composts or other substances rich in organic matter are not put into land under cultivation, or fed on it, it soon becomes unduly deprived of organic matter. And the soil is thus deteriorated as a medium for the growth of roots and for the retention of moisture, and as a store of fertility gradually becoming available for the nourishment of crops.

During very dry or cold seasons, and even during very wet ones, the want of organic matter in the soil is a source of danger to the crop. The fate of many plots at the stations during the recent drought showed how intimately the fertility of the land, and the health and safety of the crop, are concerned in the accumulation of organic matter in the soil.

Quick-acting Manures and Organic Matter. — However much, therefore, we may commend the application of quick-acting light manures—phosphates, nitrates, and potash salts—for the assistance of crops, it is quite evident that their proper position on most kinds of land is subordinate to that of the heavier manures and to the slowly acting manures rich in organic matter, which perform the important work of building up the fabric of the soil, and accumulating therein a reserve of fertility which is commonly known under the name of "condition," and which is also called "backbone" by those who are able to appreciate its importance.

OTHER RESEARCH WORK BY THE HIGHLAND AND AGRICULTURAL SOCIETY.

In more recent years the Highland and Agricultural Society has conducted a large amount of research work in various directions, part of it under the supervision of Mr James Hendrick, F.I.C., who succeeded Dr Aitken as chemist to the Society in 1904. Useful experiments have been carried out at different times on the fattening of cattle and sheep with different foods, on the effects of food upon the milk yield of cows, on the effects of various manures as top-dressing for grass-land of different character, on the produce of different varieties of oats, on the "boxing system" of preparing seed-potatoes, and on other questions of practical interest to farmers. The lessons to be derived from most of these investigations are made use of in different parts of this work.

EXPERIMENTS BY THE ROYAL AGRICULTURAL SOCIETY OF ENGLAND.

The Royal Agricultural Society of England has, from time to time, carried out a great amount of valuable experimental work. Most of this work has taken place at the Society's Experimental Farm, near Woburn, Beds, the use of which was offered, in the year 1876, to the Society by Hastings Russell, 9th Duke of Bedford. This Station has since been maintained almost entirely by the generosity of successive Dukes of Bedford, the superintendence, management, and expert advice being provided by the Royal Agricultural Society.

The Woburn Experimental Farm consists of about 140 acres, of which 100 are arable and the rest in grass. The soil is a light sandy loam, with subsoil of sand, and it belongs to the Lower Greensand formation. It is well suited for sheep-feeding and the growing of barley and potatoes. There are, in addition to a residence for the farm manager, suitable farm buildings, and specially arranged feeding-boxes for carrying out experiments on cattle, together with weighbridge, oil-engine, &c.

Pot-culture Station.—In 1897, and mainly as the outcome of a bequest from the late Mr E. H. Hills, a Pot-culture Station was added. This was built and equipped by the Royal Agricultural Society of England, at a cost of £1200, and is the first and the most complete of the kind erected in this country. It consists of a laboratory, a conservatory, and a spacious wired-in enclosure. It is in close proximity to the farm buildings.

The Staff.—The resident staff of the entire experimental station consists of a farm manager, with foreman, and six to seven farm hands; at the laboratory a chemist and a laboratory lad are also employed. The whole of the work of the Station is under the charge of the Chemical and Woburn Committee of the Royal Agricultural Society, the director of the entire experimental work being Dr J. A. Voelcker, the chemist to the Society.

Objects of the Woburn Experiments.—The inception—in 1876—of the farm was due to two main causes:

(1) The desire to put to the test, on a light soil, the results of the world-renowned experiments of Lawes and Gilbert on the continuous growing of wheat and barley, which had been conducted since 1843 on the heavy soil of Rothamsted (Herts).

(2) The desirability of testing in actual practice the accuracy of Lawes' and Gilbert's tables for fixing the compensation value of the unexhausted manure produced by the consumption, on the farm, of different purchased foods.

In regard to the former, it had often been asked whether the striking results obtained in Lawes' and Gilbert's experiments on a heavy soil would be borne out on a light one; while, in regard to the second question, the subject of compensation to an outgoing tenant for purchased foods consumed on the farm had derived special significance because of the passing of the Agricultural Holdings Act of 1875.

At the outset, the plan of the experimental inquiry was laid down by Sir John Lawes and the late Dr A. Voelcker, Dr Voelcker shortly afterwards taking sole charge and so continuing until his death in December 1884, after which he was succeeded in the Direction by his son, Dr J. A. Voelcker, the present chemist to the Society, to whom we are indebted for the subjoined notes.

Though the farm was originally intended for the elucidation of the above two questions, the work rapidly extended, and while the main experimental field (Stackyard Field) of 27 acres has been rigorously kept for these strictly scientific inquiries, a large number of other experiments, either supplemental to the foregoing or of general farming interest, have been, from time to time, added, so that the whole is now essentially an "experimental farm" in the wide sense.

Scope of the Work.—Not only have there been experiments on the manuring of different farm crops, but also on the introduction of new crops, and of new varieties, feeding experiments on cattle and sheep, and the testing of different agricultural questions, such as the value of ensilage, the losses in making and storing farmyard manure, green-manur-

ing, the inoculation of leguminous crops, the prevention of "finger-and-toe" in turnips, the combating of "potato disease," &c.

At the Pot-culture Station, moreover, a very large and varied series of experimental work has been carried out, partly in conjunction with the field experiments, and partly on such inquiries as the influence on plants of some of the rarer constituents found in soils (the Hills' experiments), the prevention of fungoid diseases, the eradication of weeds, &c. The station is, further, a reporting one of the Meteorological Department, and observations are regularly taken and recorded of rainfall, temperature, dew-point, &c.

Stackyard Field.—The principal experimental field is Stackyard Field, 27 acres in extent. It is somewhat inconveniently situated, being one mile from the farm buildings. In other respects this disadvantage is more than made up for, inasmuch as the level situation, the even character of the soil throughout, and the ready response of the land to manurial agents applied to it, make the field an ideal one for experimental work. At the outset the soil of the field was sampled in different spots over the whole area, and analyses made of the samples thus taken showed the whole field to be of exceptionally uniform character. This has further been borne out by practical experience, duplicate plots similarly treated having given results in close agreement with one another. The following analyses represent the general composition of the soil of the field:—

(SOIL DRIED AT 100° C.)

	1st depth of 9 inches.	2nd depth of 9 inches.
[1] Organic matter and loss on heating	4.132	2.432
Oxide of iron	2.934	2.571
Alumina	3.610	2.840
Lime	.308	.205
Magnesia	.143	.162
Potash	.286	.235
Soda	.140	.217
Phosphoric acid	.156	.115
Sulphuric acid	.027	.023
Insoluble siliceous matters	88.264	91.200
	100.000	100.000
[1] Containing nitrogen	.166	.094

The top-soil is about 9 inches deep and of reddish colour, the subsoil being more yellow and sandy in character. The fact of the soil being poorly supplied in lime (as shown in the analysis) has brought out results of peculiar significance. But, apart from this, it may be said that the soil is one that is peculiarly responsive to any manurial treatment applied to it. Further, though light in nature, it does not suffer greatly, either in extremely dry or in very wet weather.

Continuous growing of Wheat and Barley.

These experiments are the complement — on a light soil — of the older Rothamsted experiments. The object is, primarily, by growing the corn crops year after year, and adopting the same manurial treatment each year, to ascertain what is the effect, on the crop, of the different manurial constituents of the various applications. Further, to ascertain what these will produce when used in differing amounts, and what may be learnt regarding the nature of their action.

It must be pointed out that these experiments had not, in the first instance, any direct bearing on the question as to whether it would "pay" to grow corn year after year on the same land, nor as to which of the applications would give the greatest money return; but they were distinctly scientific experiments for the purpose of ascertaining the action, both on crop and on soil, of the different applications. From them it is possible, certainly, to deduce conclusions as to what will be successful or otherwise in actual practice, but the main purpose was, as stated, to establish the principles of the action of different manurial constituents.

Five and a half acres of Stackyard Field are devoted to this work, 2¾ acres being every year in wheat and 2¾ acres in barley.

The varieties of wheat and barley grown on the respective areas are changed from time to time. The plots are, as a rule, ¼ acre each in extent, some, however, having been subdivided as the work progressed.

In each case there are two unmanured plots, one at either end of the field; there are plots with nitrogen supplied in

the form of ammonium-salts (sulphate of ammonia and muriate of ammonia in equal quantities), of nitrate of soda, of farmyard manure, and of an organic manure (rape-dust). The nitrogen is applied in different amounts, and either alone or with mineral manures, these latter consisting of superphosphate of lime, and the sulphates of potash, soda, and magnesia. The effect of omitting the nitrogenous applications for a year, or for longer periods, is also studied, and, of later years, the effect of applying lime in addition to ammonium-salts has been observed, and important conclusions have been drawn from this part of the work.

The farmyard manure used is made by bullocks consuming in the feeding-boxes known quantities of decorticated cotton-cake, maize-meal, hay, straw-chaff, and roots, and being supplied with known amounts of straw as litter. The foods are analysed, and deduction is made for the constituents used in giving the increase in live-weight of the animals, so that the manure applied is of approximately known composition.

The harvest results are tabulated for each year, and as the first crop was taken in 1877, the year 1896 marks the conclusion of the first twenty years, and the year 1906 that of the next ten years (thirty years in all), of the continuous experiments both with wheat and barley. These results are summarised in Table I., opposite.

Continuous Growing of Wheat.

In the first place, it will be noticed that wheat has been grown year after year for thirty years without any manure being applied. For the first twenty years the average produce was 15.3 bushels per acre, this falling in the next ten years to 10.8 bushels (the results of plot 7 are taken, as plot 1 is somewhat affected now by trees near it). Mineral manures alone (plot 4) have not increased the crop at all, but when used with nitrate of soda (plots 6 and 9*a*) have given marked increases. The heavier applications of nitrate of soda, with the minerals, have not, however, given proportionate increase in crop. Nitrate of soda used alone (plot 3) continues to give fair yields even after thirty years, but ammonium-salts have afforded exceptional and unexpected results.

While for twenty years ammonium-salts (plot 2*a*) did as well as nitrate of soda (plot 3), after this period the crop began to fail, getting worse each year; the soil was found to have become quite acid and to be capable of doing little more than grow the weed spurry (*Spergula arvensis*) in abundance. On the soil, too, a mossy green mould was found to spread. Lime was then applied, at the rate of two tons per acre, in December 1897 (plot 2*b*), when the spurry disappeared, and the wheat crop was again restored, the effect of the application still telling after an interval of ten years. Plots 8*a*, 8*b*, and 9*a*, 9*b*, show the result of applying (along with minerals) ammonium-salts and nitrate of soda respectively one year and leaving them off the next year. When nitrate of soda is left off for a single year the produce goes down nearly to the unmanured yield, but not to such an extent when ammonium-salts are left out, thus showing that nitrate of soda is exhausted in a single year, but ammonium-salts not so entirely.

Next, rape-dust, supplying 100 lb. of ammonia per acre, has done as well as farmyard manure giving twice that amount, and where either of these have been put on for several years and then left off, the effects of their application are still noticeable after an interval of twenty years, thus showing the "lasting" character of farmyard manure as compared with nitrate of soda and ammonium-salts.

Continuous Growing of Barley.

The results follow very much the lines of the wheat experiments. The unmanured produce was 21 bushels for the first twenty years and 12.4 bushels for the next ten. Mineral manures used alone have given a small increase, but much larger ones when in combination with nitrogenous salts. As in the case of wheat, there has been no failure with nitrate of soda used by itself, but the results with ammonium-salts have been of an even more striking character than with wheat, the failure coming earlier and being more marked. The recovery when lime was used was similarly very

striking and equally lasting. With rape-dust and farmyard manure the results were much as with wheat, though the farmyard manure proved rather the superior.

Practical Conclusions from the Continuous Growing of Wheat and Barley.

It follows from the above experiments that both wheat and barley can be grown

TABLE. I.—CONTINUOUS GROWING OF WHEAT AND BARLEY.

(Stackyard Field, Woburn.)

Average results of first twenty years (1877-1896) and next ten years (1897-1906).

Plot.	Manures applied annually per Acre.	WHEAT.		BARLEY.	
		Average Produce of Corn per Acre.			
		First 20 years. (1877-1896).	Next 10 years. (1897-1906).	First 20 years. (1877-1896).	Next 10 years. (1897-1906).
		bush.	bush.	bush.	bush.
1	Unmanured every year	14.7	8.6	21.9	11.5
2*a*	Ammouium-salts containing 50 lb. ammonia	23.8	9.7	33.5	4.8
2*b*	Do. with 2 tons lime, December 1897	...	16.8	...	21.2
3	Nitrate of soda containing nitrogen equal to 50 lb. ammonia	23.6	17.0	35.6	23.6
4	Mineral manures	15.1	8.2	22.5	16.2
5*a*	Do. and ammonium-salts containing 50 lb. ammonia	30.2	24.4	39.0	7.1
5*b*	Do. and ammonium-salts with 2 tons lime, December 1897	...	...	...	33.8
6	Do. and nitrate of soda containing nitrogen equal to 50 lb. ammonia	31.2	23.6	43.5	35.3
7	Unmanured every year	15.9	10.8	20.5	13.3
8*a*	Mineral manures and, in alternate years, ammonium-salts containing 100 lb. ammonia	37.2	25.4	45.4	14.5
8*b*	Mineral manures, ammonium-salts omitted in alternate years	23.1	17.6	31.0	12.7
8*aa*	Same as 8*a* with 2 tons lime, December 1897	...	...	...	38.0
8*bb*	Same as 8*b* with 2 tons lime, December 1897	...	...	...	28.3
9*a*	Mineral manures and, in alternate years, nitrate of soda containing nitrogen equal 100 lb. ammonia	34.0	29.1	49.3	42.8
9*b*	Mineral manures, nitrate of soda omitted in alternate years	16.4	11.8	31.1	23.4
10*a*	No manure since 1890, after rape-dust for 1 year. Previously for 5 years farmyard manure equal to 100 lb. ammonia	15.3	12.7	22.9	16.7
10*b*	Rape-dust (about 14 cwt.) equal to 100 lb. ammonia annually since 1890	27.2	26.6	37.4	33.4
11*a*	No manure since 1882. Previously for 5 years farmyard manure equal to 200 lb. ammonia	18.7	14.1	32.6	21.9
11*b*	Farmyard manure (about 7 tons) equal to 200 lb. ammonia annually	27.2	24.0	39.9	36.6

NOTE.—Ammonium-salts are equal weights of sulphate of ammonia and muriate of ammonia. Mineral manures are: 3½ cwt. superphosphate of lime, 200 lb. sulphate of potash, 100 lb. sulphate of soda, 100 lb. sulphate of magnesia, per acre.

perfectly well on the same land year after year if the proper manures be used. If the land be kept clean and free from weeds it may go on producing moderate crops even when no manure is used. Mineral manures alone do not increase the yield, but the proper manuring for both crops is a combination of mineral manures with nitrogenous salts such as nitrate of soda or sulphate of ammonia, or else organic manures such as farmyard manure or rape-dust.

While the influence of nitrogenous salts lasts practically only for the year of their application, that of farmyard manure will not be entirely exhausted even in twenty years' time. Lastly, on land naturally poor in lime, sulphate of ammonia will, sooner or later, exhaust the land and render it acid. The remedy for this is to be found in the application of lime, the influence of a single dressing of two tons to the acre lasting for ten years subsequently.

Though it has not been possible to give, in the compass of a single table, more than an outline of the results, there have been recorded many other observations—*e.g.*, those on the produce of straw and the quality of the grain. For these, reference must be made to the Journals of the Royal Agricultural Society of England.

It may be said, in general, that the results are in direct confirmation of those obtained at Rothamsted, and that to the latter have been added important contributions, mainly in regard to the influence of ammonium-salts on a soil poor in lime, the restoring effects of lime, and the duration of farmyard manure. The Woburn Experimental Farm is, indeed, the first one in any country where these striking results as regards the action of salts of ammonia and of lime have been brought out.

At the close of the thirtieth year (1906) further modifications of the original plan were introduced. These consist of (*a*) simplification of, and alterations in, the quantities of the artificial manures used, these being lowered to amounts commonly used in farming practice; (*b*) the use of lime in different quantities (5 cwt., 10 cwt., and 1 ton per acre); (*c*) the substitution of plots 10*a* and 11*a* by others in which the influence of potash and of phosphates is separately tested.

The Rotation Experiments.

The next series of experiments is that on rotation, the primary purpose of these being to put to the test, in actual practice, the accuracy of Lawes' and Gilbert's tables for the unexhausted value of manure produced by the consumption of feeding-stuffs by animals on the farm. The attempt was now made, by selecting two foods in Lawes' and Gilbert's tables —decorticated cotton-cake and maize-meal—and feeding them to animals on the farm, to see whether the manure left over after their consumption was capable of producing in increased crops results commensurate with the theoretical values assigned to them in the tables.

At the outset (1876) decorticated cotton-cake and maize-meal respectively were fed—with other foods—to two sets of bullocks in the feeding-boxes, and the resulting manure was used for growing a root crop; the roots were removed and a barley crop taken, clover was sown among the barley, the clover fed off by sheep, which received in addition decorticated cotton-cake in one case and maize-meal in the other; after this a wheat crop followed.

This course was pursued for two entire four-course rotations (1877-1884), at the close of which it was found that, taking everything together, the highly nitrogenous decorticated cotton-cake had done practically no better than the maize-meal, which latter was very poor in nitrogen. But, on examining the results more closely, it was found that the poorer maize-meal had produced crops which were quite up to the average of well-manured land on this class of soil, and hence it was not to be expected that the maximum produce could be exceeded by further manuring, so that the richer decorticated cotton-cake did not have a fair chance of showing its superiority. The land, in fact, had been over-manured, it was believed.

Hereupon a change was introduced in the manurial plan, and, from 1884 on, the crops of the rotation were only manured once in the four-course duration. The root crop, instead of being manured with decorticated cotton-cake dung and maize-meal dung respectively, was merely grown with a little superphosphate to give it a start; the root crop was fed off by sheep with decorticated cotton-cake on one portion and maize-meal on another; barley followed, then clover; but this latter was not fed off as before with cake and meal, but was cut and removed as hay, while wheat followed without further manure.

This plan was followed on one half of the original area, while on the other

half the same four crops of the rotation were simultaneously grown, but without any manure, and they were all removed off the land. This was done with the intention of exhausting the believed over-fertility, and of seeing, if possible, whether by this method the previously applied decorticated cotton-cake would show its superiority over the maize-meal similarly applied. This plan was continued for another three rotations (12 years, 1885-1896), but, at the close, the results were very little more definite than in the former instance.

It was found, indeed, that the barley crop which immediately followed the cotton-cake manuring was in all cases superior to that after the maize-meal manuring, but the subsequent crops showed no differences, and, indeed, the wheat crop following the clover was practically as good on the half to which no manure whatever had been applied since 1884 as that on the manured half. This, it must be pointed out, however, was the case so long as clover was the preceding crop, and, with but few exceptions, it was found possible to grow a clover crop once in the four years.

Hellriegel's Discoveries.

During this interval the classic discoveries of Hellriegel came to light, and these supplied an explanation of the failure of the experiment to bring out the points expected. By showing that clover was able to obtain its supplies of nitrogen from the air, Hellriegel explained what had been long known in practice—how it was that wheat after clover needed no nitrogenous manuring. So here, at Woburn, as long as the clover crop could be grown, the land was being enriched with nitrogen, and further manuring could do no good, so that the differences between decorticated cotton-cake and maize-meal, due to the higher nitrogen of the former, could not be brought out, for, after the clover crop, the wheat was just as good whether decorticated cotton-cake, or maize-meal, or nothing at all was used.

Accordingly this long series of work, though seemingly failing in its ultimate object, afforded most striking proof of the practical application of Hellriegel's nitrogen theory.

A Change in Plan.

It was found hopeless, therefore, to attack the problem of unexhausted manure value in this way, and the next step was to devise a plan of rotation in which the disturbing influence of clover should not enter. But, as a preliminary, it was necessary to get the land—hitherto unevenly manured—into a uniform condition of fertility again, so that future work might begin on a fair basis. To effect this, crops of barley—all without manure—were grown year by year for the next 8 years (1897-1904), the produce of each plot being weighed as before, and this was continued until the land showed uniform results, after which (1905) the new series was begun.

In the new plan clover or other leguminous crop is omitted altogether, a green crop (mustard) taking its place. The experiment is in two parts—the one to represent the use of decorticated cotton-cake (or maize-meal) on light (sheep) land, where the cake is given to the sheep as they feed off the roots; the other to represent the practice on heavy land, where the cake or meal is fed to bullocks in the yards, the manure being carted out and spread for growing the root crop. Barley in each case follows the root crop, then the green crop (mustard) is cut or ploughed in, and wheat follows. In this way it is hoped to ascertain, by the crops grown subsequent to the manurial application, what the difference in manurial value is between decorticated cotton-cake and maize-meal, whether fed direct on the land or consumed in the yard and carted out as manure.

Green-manuring Experiments.

When attention was called, by Hellriegel's discoveries, to the important *rôle* played by leguminous crops, it was resolved to try the practical application of the theory in the growing of cereal crops in alternation with leguminous ones. If it be the case that leguminous crops, by utilising the nitrogen of the air, enrich the soil in nitrogen to an extent that non-leguminous do not, then it may be reasonably argued that the cheapest manuring for a cereal crop is to grow a leguminous green crop before it; and,

similarly, if two green crops be grown, the one leguminous and the other non-leguminous, then the corn crop following the leguminous green crop ought to be much the better because of receiving the nitrogenous manuring stored up in the soil as the result of the growing of the leguminous crop. This latter point it was resolved to put practically to the test.

Lansome Field was selected, and three plots were set out on it. On one of these tares (leguminous) were grown, on a second rape, and on a third mustard (both the latter non-leguminous). Two crops of each were grown during the season and successively ploughed in green, barley following in the next spring. Moreover, that failure to ensure nitrogen-assimilation might not be due to need of mineral applications, superphosphate and sulphate of potash were given to one half of each plot, and lime to the other half.

After carrying on the experiment for three successive barley crops, it was invariably found that the barley after mustard was the best crop of the three, then that after rape, and that after tares —contrary to theory—the worst of the three.

Wheat was then substituted for barley as the corn crop, as it was thought that possibly the accumulated nitrogen might be removed by drainage in winter. Also winter tares were substituted for spring tares in order to give the crop a longer hold on the soil. But the same results were forthcoming whether barley or wheat was the crop, whether manured with minerals or not, whether tares were spring- or winter-sown: in all cases the best corn crop followed the growing of the non-leguminous green crop, mustard, and the worst was that after the leguminous crop, tares. Even when after a wheat crop a barley crop was next taken (in case the nitrogen had not become available in the first season), no different results were obtained. The experiments were too often repeated to admit of any doubt, and one is forced to the conclusion that, so far at least as concerns the growth of the tare crop on land of this light sandy character, the theory does not hold good in practice.

In order to see that more nitrogen was actually being supplied by the tare crop, this and the mustard crop were, one year, cut, weighed, and analysed, and the tares were found to be supplying twice the amount of bulk, of organic matter, and of nitrogen, that the mustard did. The experiments are still in progress, and, side by side with them, investigations are going on at the Pot-culture Station close by with a view to supplying the explanation of these unexpected results. The work, so far, points in the direction of the differences being due to considerations of changes produced in the mechanical texture of the soil and of its water-holding capacity.

Other Experiments with Corn Crops.

From time to time different experiments have been conducted in order to ascertain the relative yielding powers of different varieties of wheat, barley, and oats. These, of course, have reference particularly to the soil of the farm, but it may be mentioned that foreign malting barleys, such as "Hauna," "Bohemian Chevalier," and Californian barleys, have been tried, also different kinds of Canadian wheat. With these it has been found universally the case that, while in the first year of their growth they exhibit their characteristic qualities, these disappear almost entirely upon the seed thus obtained being grown for a second season.

Other trials with corn crops have concerned the selection of seed, and experiments both with wheat and barley have shown that it is not the plump, well-grown seed which of necessity produces the largest crop, the same weight of smaller grains producing quite as good a return.

The kiln-drying of barley constituted a further inquiry, the result being to show that, unless in an exceptionally wet year, no benefit accrued from the kiln-drying.

Manurial experiments have been conducted with soot as a top-dressing for wheat, these showing that a dressing of 40 bushels per acre of good soot is quite as effective as one of 1½ cwt. per acre of nitrate of soda. At the same time, it was shown that applications of 60 and 80 bushels per acre of soot are needlessly large if the quality of the soot be good.

Experiments with Potatoes.

For several years in succession the spraying of potatoes with "Bordeaux mixture" (sulphate of copper and lime), to counteract "potato disease," has been carried on. In years when disease is prevalent the spraying undoubtedly wards off the disease, and gives profitable results; but when disease is not rampant, though the crop is slightly increased through its period of growth being prolonged, this does not "pay" for the application. An interesting series of manurial experiments on potatoes has also been carried out for several years in succession with the object of ascertaining whether nitrate of soda or sulphate of ammonia is the better nitrogenous manure for potatoes, and whether kainit or sulphate of potash is to be preferred as a source of potash.

The results have come out very uniformly, and have shown that while sulphate of ammonia has done rather better than nitrate of soda, there is a marked advantage possessed by sulphate of potash over kainit. A general artificial dressing which has proved most effective for potatoes on light land is—dung, 12 loads, with superphosphate 3 cwt., sulphate of potash 1 cwt., sulphate of ammonia 1 cwt., each per acre.

Different varieties of potatoes have further been tried in regard both to their cropping powers and their liability or otherwise to disease.

Experiments with Mangels.

The principal manurial experiment on the mangel crop has concerned the use of nitrate of soda as a top-dressing, with or without the addition of common salt. When dung—say 12 loads per acre—has been used, it has been found that a top-dressing of 1 cwt. per acre of nitrate of soda with 1 cwt. per acre of salt has been more effectual than the dung used with 1 cwt. of nitrate of soda, or even with 2 cwt. of nitrate, when salt is omitted altogether. This result has been confirmed by repetition in several successive years.

"Finger-and-Toe" in Turnips.

The application of different materials which have been suggested for the prevention of "finger-and-toe" in turnips has been tried, among these being sulphate of iron, sulphate of copper, bleaching-powder, kainit, common salt, borax, &c. Of all the applications tried, only those which contained lime in quantity have been of any use, lime itself being the best, then gas lime. Basic slag did good for a time, but not permanently.

Experiments with Clover.

Experiments have been devised with a view to obtaining an explanation of the so-called "clover-sickness," but no manurial applications have been found to prevent this. Also trials with "nitragin" and similar inoculating materials have failed to reproduce the benefits attributed elsewhere to the use of these materials.

Different varieties of clover, including some received from Canada, Chili, and elsewhere, have been grown, but none have been found superior to the ordinary English red clover.

Experiments on Lucerne.

The influence of manurial ingredients in prolonging the growth of lucerne has been tried for many years. Though the soil is a light sandy one, very poor in lime, lucerne has been successfully grown and kept down for as many as thirteen years. Both nitrate of soda and sulphate of ammonia, when used alone, were found to be harmful, but sulphate of potash gave fair crops. The only really good crops, however, were those to which a mixture of artificial manures comprising superphosphate, sulphate of potash, and either nitrate of soda or sulphate of ammonia had been applied, so that potash would seem to be an essential element in the case.

In recent years different varieties of lucerne — viz., from Provence seed, American seed, and Canadian seed — have been grown, the Canadian seed giving decidedly the best return.

Pasture Experiments.

In 1886 a field (Great Hill Bottom) was laid down with different mixtures of grasses, and at different cost, some containing rye-grass and some not, and this with the object of seeing whether the rye-grass was permanent or not, and

if its inclusion in a seed-mixture was to be recommended. The general result has been to show that the rye-grasses have remained constituent parts of the pasture, and have even invaded the plots on which they were not originally sown.

Manurial applications on this field also brought out the important result that, while basic slag (8 cwt. per acre) used alone exercised no benefit, this same quantity used along with 1 cwt. per acre of sulphate of potash caused a wonderful improvement, and increased the growth of clover remarkably.

Two plots laid down later (1901) in this field with Elliot's mixtures of deep-rooting plants (which include kidney-vetch, burnet, and chicory) have been very successful, and they still (1908) remain quite good.

Manurial experiments in other fields (Broad Mead and Long Mead), in which farmyard manure, lime, basic slag and sulphate of potash, and superphosphate with sulphate of potash, are compared, have given the best yields with the two latter mixtures. Botanical examination of the hay has further shown that where the potash salts are used the percentage of leguminous plants is increased markedly.

Introduction of New Crops.

From time to time crops new to the land have been tried — *e.g.*, *Lathyrus sylvestris*, maize, kohl-rabi, crimson trifolium, white trifolium, gorse. The two former were proved to be useless for the land, the lathyrus not being relished by stock; gorse, also, though readily enough taken by stock, failed to be practically useful because of the want of a proper machine to bruise or crush it adequately and economically; kohl-rabi and trifolium, however, though formerly not known to the neighbourhood, have now become regular crops of the farm.

Ensilage Experiments.

An extended inquiry was made into the subject of ensilage during the years 1884-7, both silos and silage-stacks being erected, and feeding experiments were conducted on bullocks with the produce. In this way the respective losses incurred in making silage and in making hay were ascertained, and a comparison was instituted between feeding bullocks on roots and hay and on silage respectively. The feeding with silage was not quite as good or as economical as that with roots and hay, and though it was established that silage was profitable whenever hay could not be made or roots were scarce, no further advantage could be claimed for it.

Feeding Experiments.

From the outset, feeding experiments both with bullocks and with sheep have been carried out, the latter in the open, the former in the eight specially erected feeding-boxes or "pits" at the farm. Besides the ensilage experiments already referred to, different foods have been compared in respect of their use for fattening cattle. Thus, the superiority of a mixture of decorticated cotton-cake and maize-meal over linseed-cake has been shown, and that of decorticated cotton-cake over undecorticated cake.

Losses with Farmyard Manure.

From the making of farmyard manure in the feeding-boxes, by bullocks consuming known quantities of food, important results have been obtained as to the losses incurred in the making and in the storage of farmyard manure. The manure has been analysed when made in the boxes, and again when removed from the heap after storing, and the result has been obtained that, even under the best conditions, farmyard manure loses about 15 per cent of its nitrogen during the making, and another 20 per cent during storage, so that one can say that under ordinary conditions only about one-half of the nitrogen originally passing out of the animal finds its way on to the land.

This has, of course, an important bearing on the question of compensation for unexhausted manure.

Pot-culture Station.

Last to be mentioned is the most recent development in experimental work, that of the Pot-culture Station, where a very large number of inquiries are being carried on. These are partly independent inquiries, such as those forming the Hills' Bequest work, in which the in-

fluence of the "rarer constituents" of plants are being studied. In this connection different salts of lithium, manganese, iodine, bromine, &c., have been experimented with, and the results show that these, even when used in minute quantities, have a marked influence, more particularly on germination.

Other matters, such as the "hardness" or "softness" of wheat, the prevention of smut in grain, the destruction of weeds, and the relative thickness of sowing of grain, are being investigated.

To a large extent, however, the Pot-culture Station is made use of in direct connection with the field experiments, and for the solution of problems that have arisen in the carrying on of these latter. Thus, the questions of acidity in the soil of Stackyard Field, produced by continued manuring with ammonium-salts, and its correction by the use of lime and other means, are being worked out, together with the collection of data regarding the removal of lime from the soil by nitrate of soda and different salts of ammonia. The field green-manuring experiments are also being more closely studied here, together with other soil problems, such as the physical changes produced by different salts, and the influence of magnesia in its relation to lime according as these two may exist in a soil.

By means of the Pot-culture Station a great deal of light is being continually thrown upon what has been noticed to take place in the field experiments, and further ways of developing inquiry are being constantly desired.

Within recent times the Pot-culture Station has also been utilised for conducting inquiries, on behalf of the Board of Agriculture, on the value of inoculating materials for leguminous crops, and for the Royal Commission on Sewage Disposal, on the value of different sewage sludges.

ABERDEENSHIRE EXPERIMENTS.

The following account of experiments carried on by the Aberdeenshire Agricultural Association was, at the request of the Editor, prepared for the Fourth Edition of *The Book of the Farm* by Mr Thomas Jamieson, F.I.C., chemist to the Association, who has all along had the active management of the experiments.

The experiments were commenced in 1875. They had been framed with great care, scrutinised and amended by several gentlemen conversant with the various aspects of the question, chiefly by the late Mr J. W. Barclay, who was familiar with the manure trade and with farming, and had given close attention to the scientific aspect of the question; by Mr John Milne, Mains of Laithers, farmer, manure manufacturer, and holder of the Highland Society's diploma; by the late Mr Ranald Macdonald, factor on the Cluny estates; and by the chemist to the Association.

The Experimental Stations.—Five different sites were fixed upon, at altitudes varying from 1 to 400 feet above sea-level; at distances from the sea varying from 2 to 30 miles; representing soils of different characters and different degrees of fertility, the depth of mould varying from 8 to 36 inches; while the subsoils represented crumbling granite, gravel, and sand, yellow clay, bluish clay, and stiff red clay.

Size of Plot.—Each site was about two acres in size, and was enclosed by a substantial fence. This area gave space for a large number of plots, of the size that had been so highly recommended by the late Professor Anderson, chemist to the Highland and Agricultural Society—viz., $\frac{1}{112}$th part of an acre.

It may be mentioned in passing that Professor Anderson arrived at this size after much experience with experiments on a larger scale. It may also be mentioned that the same experience was got in Aberdeenshire,—preliminary experiments on $\frac{1}{10}$th and on $\frac{1}{20}$th acre plots having been made, while along with the large number of $\frac{1}{112}$th acre plots a large field was divided into $\frac{1}{4}$th acre plots. This experience gradually led to a clearer discernment of the objectionable features of large plots, and to a distrust in their results: at the same time, Professor Anderson's opinion was abundantly confirmed, that the $\frac{1}{112}$th acre plot is a most suitable size for field experiments, while it is also very convenient for calculation, as every pound of manure applied, or of

crop reaped, represents the same number of cwts. per acre.

Discussion as to Size of Plot.—It is only what is to be expected, that this subject of size of plot will crop up every now and again—familiarity with work on large areas engendering a leaning towards large experimental plots, while greater familiarity with actual experimenting leads to the small plot, as ensuring uniformity of soil, as well as identical cultivation under the same climatic conditions, and hence fair comparison. The $\frac{1}{112}$th acre plot is indeed too large; but it is probably as small as can be adopted, unless the soil is actually taken up, thoroughly mixed, and returned in equal quantities to the former position. Under such arrangement the $\frac{1}{1000}$th acre plot will be found in the highest degree satisfactory.

It is interesting to notice how steadily opinion grows in favour of small plots, and how constantly the above experience is repeated—namely, that every beginner, especially if associated or influenced, directly or indirectly, with practice on the large scale, begins with large plots, gradually works towards the smaller ones.

Duplicated Plots.—Especial care was taken to have each experiment duplicated, a feature too often neglected in experiments. It is indeed desirable that they should even be triplicated.

In the experiments having reference specially to phosphate applied with and without nitrogen, particular care was taken that there should be no hindrance to the action of these essentials by the absence of other materials understood to be essential. This was prevented by the application, all over the plots, of a mixture consisting of 3 cwt. potassic chloride, 1 cwt. magnesia sulphate, and ½ cwt. common salt. Each plot was surrounded by a deal-board 9 inches deep, driven edgewise into the soil.

Adjusting the Manures.—The soils were subjected both to chemical and mechanical analyses. The manures were also analysed, and care taken that equal quantities of the ingredients were used. In the earlier experiments, however, the proportion of insoluble phosphate was a half more than soluble phosphate,—an adjustment considered necessary in order that the two phosphates might be fairly compared, assuming that the finer division or greater distribution of the soluble phosphate would give it undue advantage in a fair trial of the relative powers of the two substances. Possibly this adjustment was unnecessary: the probable effect was to provide a larger quantity of phosphorus in the case of the insoluble form than was requisite. In the later experiments, therefore, equal quantities were adopted, with about the same result as had previously been got in the crop. In the first instance, also, the soluble phosphates were exactly a half soluble (*i.e.*, in commercial terms, about 20 to 26 per cent superphosphate). In the later experiments, however, the highest practicable degree of solubility was sought—viz., about 35 per cent soluble.

On singling the plants (turnips) it was sought to have an equal number in each plot—namely, about 200; but that number, from various causes, which will be easily understood by those engaged in practice, was seldom maintained to the end of the season. Attacks by insects, weakly plants, frost, drought, &c., frequently reduced the number.

None of the operations on the plots were allowed to go on, nor weighing of the crop, except in the presence of the chemist who directed the experiments.

It may thus be seen that the most scrupulous care and attention were given to the whole work.

First Year's Conclusions.

At the end of the year the numerous and duplicated results of this large series of experiments were tabulated, and presented such a varied and confirmed series of results as probably had not previously been available. They were carefully considered by the individuals above mentioned, and others taking part in the direction, and finally the following conclusions were adopted :—

1. That *phosphates of lime* decidedly increase the turnip crop, but that farmers need not trouble themselves to know whether the phosphates are of animal or of mineral origin.

2. That soluble phosphate is not superior to insoluble phosphate to the extent that is generally supposed.

3. That nitrogenous manures have

little effect on turnips used alone, but when used along with *insoluble* phosphates increase the crop; that the addition of nitrogen to *soluble* phosphates does not seem to increase the solids or dry matter in crop; and that there is no material difference between the effects of equal quantities of *nitrogen* in nitrate of soda and in sulphate of ammonia.

Note.—Pure sulphate of ammonia contains about 5 or 6 per cent more nitrogen than nitrate of soda.

4. That fineness of division seems nearly as effective in assisting the braird and increasing the crop as the addition of nitrogenous manures. Hence the most economical phosphatic manure for turnips is probably insoluble phosphate of lime, from any source, ground down to an impalpable powder.

Condensed Results.—It would occupy too much space to give the results in detail. It may suffice to give a few condensed results—namely, a few results from the station that responded best to the action of phosphate, and therefore showed the relative action of the different forms most clearly; and also the results of the five stations averaged :—

		Aboyne.	Average of 5 Stations.
		Turnips. Tons per acre.	Turnips. Tons per acre.
Group I.	No phosphate given	5	10
	Insoluble phosphate (ground coprolite)	19	16
	Soluble phosphate (superphosphate)	22	18
Group II.	Insoluble phosphate and nitrate of soda	21	18
	Soluble phosphate and nitrate of soda	26	21
Group III.	Insoluble phosphate and sulphate of ammonia	23	20
	Soluble phosphate and sulphate of ammonia	24	20
Group IV.	Raw bone-meal	15	16
	Steamed bone-powder	23	20

Insoluble Phosphates as Plant-food.—From the point of view of new information, the first and last groups are by far the most important. Formerly coprolite was deemed of no manurial value until rendered soluble by sulphuric acid; and in placing a money value on a dissolved manure, no value was attached to the insoluble portion it contained. The above results indicated that this position was untenable. They led the Aberdeenshire Association to say decisively that insoluble phosphate in the form of ground coprolite was directly effective on plants, and to add the statement that the superiority of the soluble form is not so great as is generally supposed. It was thought well to limit expression to the latter general and tentative statement, reserving a definite statement till further results were obtained.

The fourth group indicates the excellent results got by using phosphate in a fine state of division, and led to the fourth conclusion stated above.

It may be remarked that these opinions are now generally accepted. No doubt there may constantly be heard dissentients from these doctrines. That is only what may be expected, when the subject concerns so large a body as the whole agriculturists of a kingdom. But no responsible person will now be found to take up an opposite position.

The bearing of the New Doctrine.—At this stage there ought to be prominently brought forward the real bearing of this new doctrine on agricultural practice.

What is the actual effect of the knowledge that the natural coprolite, merely ground, is able directly to feed the plant with phosphate? Being decidedly the cheapest form of phosphate, does it follow that it should be employed to the exclusion of all other phosphates? Assuredly not, when it is so clearly brought out that although it produces 16 tons per acre, other forms produce 18 tons, and others 20 tons per acre. Assuredly not again, when it is stated that greater assistance is given to the plant in the early stage, by more finely divided phosphate, or by soluble phosphate. So long as the latter two phosphates are not charged a higher price, as compared with coprolite, than is compensated by the larger crop, they should be used. So

soon, however, as the price advances much beyond that point, the agriculturist can fall back on coprolite, which is found abundantly in many parts of the world, and requires no more manufacture than simple grinding.

It is thus wholly and solely a matter of price. And herein lies the important practical bearing of the new doctrine. It is well to grasp fully the significance of the knowledge that coprolite may be used directly. Put in few words, it is this—*that it provides a check to the undue raising of the price of manufactured phosphates.*

Experiments of Subsequent Years.

It would go beyond the limits of this article to explain the many points that engaged the Aberdeenshire Association during the following six years—viz., till 1882—during which the experiments of the first year were continued and repeated, providing altogether many hundreds of results. The proceedings of the Association, for that period of seven years, form a large volume, replete with tables, diagrams, and photographs, which provide the critic with full details, while at the same time the main points are clearly brought out for the general reader. It may suffice to say that the following points were very fully entered into:—

1. The *specific gravity of turnips*, which was found to give no reliable indication of their quality.

2. The *proportion of water in turnips*, which was found to be increased both by nitrogenous and, to some extent, by soluble phosphatic manures.

3. "*Finger-and-toe*" *disease* was investigated; farmers' opinions regarding it widely ascertained; many experiments conducted to ascertain the effect of manures in giving rise to the disease; and other experiments with the view of finding a remedy. Speaking generally, it was found that whatever weakened the plant predisposed it to disease, and rendered it an easy prey to its natural fungoid enemy, which then produced the disease. But while many influences, both mechanical and climatic, caused weakness, it was found, in a remarkable and unmistakable manner, that soluble phosphate produced this effect in a very striking degree. Nor was this effect confined to phosphate rendered soluble by sulphuric acid, but sulphur in various forms seemed more or less to have a similar effect. As to a remedy, the disease seemed lessened by whatever ensured healthy growth, or a condition of soil uncongenial to fungoid growth, as well as such lapse of time between the two turnip crops as would reduce the natural food of the fungus, while a heavy dose of lime markedly lessened the proportion of disease.

4. The *variation in weight on oat grain by storing;* the solid nourishing matter in oats differently manured; and the proportion of husk to kernel.

5. *Different methods of storing turnips* during winter were tried, and the method of storing in pits of two or three loads, and covered with three or four inches of earth, was found to answer best; while the result was not greatly different whether or not the roots or leaves, or both, were cut off previous to storing.

The first series of experiments was, as mentioned, on turnips, and turnips were grown on the same ground successively for five years.

But in the second year of the experiments, the original experiments were repeated on new ground at each station, and the effect of the various manures ascertained over a rotation.

Relative Value of Phosphates and Nitrogen.

At the end of seven years it was considered that the subject which had been carefully avoided up to that time might then be approached—viz., to fix the relative agricultural value of phosphates and nitrogen. This was done, not by attaching a money value, which might vary every year, but by fixing on some large natural source of phosphate, and a similar source of nitrogen, and adopting these each as a standard, to be referred to by the figure 10. The standard adopted for phosphate was ground coprolite of the usual commercial degree of fineness, which was called 10; while the standard chosen for nitrogen was nitrate of soda, the value of which was also called 10.

It may be necessary later on to make these standards more definite, by specifying more distinctly the precise state of mechanical division; and obviously the

finer the division chosen for the standard, the less will be the difference between it and the forms standing above it. But for the immediate purpose the commercial forms were deemed sufficient.

The values thus carefully arrived at for phosphate were:—

Phosphate of iron	0
Phosphate of alumina (redonda)	3
Tribasic phosphate of lime in bone	10
Tribasic phosphate of lime in insoluble mineral	10
Monobasic phosphate of lime in soluble phosphate	12
Bibasic or tribasic phosphate of lime in precipitated form	13
Tribasic phosphate of lime in steamed bone-flour	14

While the values for nitrogen were as follows:—

Nitrate of soda	10
Sulphate of ammonia	10
Guano	10
Nitrogen (only) in bones (supplemented with dried blood)	8

At the same time the conclusions originally framed were more specifically drawn out, as follows:—

Final Conclusions.

1. Non-crystalline phosphate of lime, ground to a floury state, applied to soil deficient in phosphate, greatly increases the turnip crop, and also, though to a less extent, the cereal and grass crops, but always with equal effect, whether it be derived from animal or mineral matter.

2. Soluble phosphate is not superior in effect to insoluble phosphate if the latter be in finely disaggregated form—*e.g.*, disaggregation effected by precipitation from solution, or by grinding bones after being steamed at high pressure. In such finely divided conditions, the difference is in favour of the insoluble form, in the proportion of about 12 for the soluble to 13 and 14 for the above insoluble forms respectively. In less finely divided form (such as mineral phosphate impalpable powder), insoluble phosphate is inferior to soluble phosphate in the relation of about 10 to 12.

3. Nitrogenous manures used alone have little effect on root crops, unless the soil is exceptionally poor in nitrogen and rich in available phosphate.

Nitrogenous manures used with phosphate on soils in fairly good condition give a visible increase of root crop, but this increase is due mostly, and often entirely, to excess of water in the bulbs.

Nitrogenous manures greatly increase cereal crops, and the increase in this case is not due to excess of water.

As to the relative efficacy of different forms of nitrogen: the ultimate effect of nitrogen in sulphate of ammonia, in guano, and steamed bone-flour, is nearly identical, whether used with soluble or insoluble phosphate. Nitrate of soda, when used with soluble phosphate, is also identical with the above forms, but is of less efficacy when used with insoluble phosphate.

4. Fine division (or perfect disaggregation) of phosphates assists the braird nearly as much as, and with more healthy results than, applications of nitrogenous manures.

The most economical phosphatic manure is probably non-crystalline, floury, insoluble phosphate of lime; the cheapest form being mixed with an equal quantity of the form in which the highest degree of disaggregation is reached.

(At present these two forms are respectively, ground mineral phosphate (coprolite) and steamed bone-flour.)

Duplicate Trials in England.

It remains only to say that, it having been argued that while these results might apply to soil in Scotland, poor in lime, and not to soils in England, generally richer in lime, it was considered desirable to ascertain whether or not the results had only this limited application.

A station was therefore established in Huntingdon and another in Kent, while later on a large number of experiments were established in Sussex, and carried on by the Sussex Association for the Improvement of Agriculture, under the same chemical direction as the Aberdeenshire experiments. These experiments in England proved that while in soil actually on the chalk formation soluble phosphate showed to more advantage than on all the other soils tried, yet as regards Sussex and Huntingdon, where the soil was not so purely chalky, but yet contained the

ordinary quantities of lime, the results were practically the same as those got in Aberdeenshire.

Outside Confirmation.

The value of these experiments in Aberdeenshire and Sussex would be uncertain unless confirmed not only in other places, but by other and independent experimenters. The importance of the question, however, was widely recognised; and after some time, both the Highland and Agricultural Society of Scotland and the Royal Agricultural Society of England established experiments on the same subject, as did also a number of private experimenters, all of whose results pointed more or less conclusively in the same direction.

Still the march has been slow, if we judge its progress by the amount of coprolite applied, or by the small effect on the superphosphate trade. But for this there are two obvious explanations: first, as already explained, that the effect is not to be looked for in the direction of the greater use of coprolite, but rather in the reduction of the prices of superphosphate and other phosphates—and this reduction has indeed taken place to a very marked extent; and, second, that the interest of the trade is more than able to cope with the agriculturist, who at the present day is hardly so skilled in the intricacies of manure as in a few years he is likely to become.

The Test of Time.

In response to the request of the Editor that he would revise the foregoing notes for the present edition of this work, Mr Jamieson writes as follows:—

"The preceding account is based on experiments made thirty-two years ago, but reperusal of it has not suggested any adjustment. It has therefore stood the test of time, and of numerous experiments since made over about one-third of a century.

Effects of the Aberdeenshire experiments.—"The effect of the discovery on the practice of agriculture has been in several directions: (1) partly in the direct use of insoluble phosphates by farmers; largely (2) in the introduction of an artificial insoluble phosphate (slag) which is extensively used in that form; (3) in the general use by manure manufacturers of insoluble phosphate in their manure mixtures, justified as they are by its proved efficacy, and encouraged by the fact that in the valuation of manures, value is now given for insoluble phosphates which formerly had been regarded as valueless; and, finally, (4) by the cheap natural insoluble phosphate being found efficacious, having lowered the price of bones and other phosphates by at least £1 per ton. As about one million tons of insoluble phosphates are used yearly in agriculture, there is indicated, on this point alone, a saving to agriculture of one million pounds sterling annually.

"The only addition that may be made is, that in these experiments it was found that for the short-lived cereal crops, and for grasses whose rootlets are beyond easy reach, soluble phosphate was more efficacious than insoluble phosphate. But since that time, attention being so much directed to the need for fine division, manufacturers are now offering so finely divided insoluble phosphate that it is probable they would act on cereals and grasses equally as well as soluble phosphate, and experiments conducted in Germany appear to have proved that this is the case."

OTHER EXPERIMENTS.

A great variety of useful experiments have in recent years been conducted by other agricultural societies, by the Irish Department of Agriculture, by private individuals, and by Colleges of Agriculture. By Colleges of Agriculture in particular the volume of experimental work now being carried out every year is very large, and is constantly on the increase. The value of this work to practical farmers can hardly be overestimated, for it has a close practical bearing upon their daily duties.

For interesting accounts of numerous important experiments the Editor of this edition is indebted to the officials of the following institutions—viz.: The Agricultural Department, Cambridge University; the Agricultural Department, Leeds University; Armstrong College, Newcastle on-Tyne; South-Eastern Agri-

cultural College, Wye, Kent; the University College, Reading; the West of Scotland Agricultural College, Glasgow; the Edinburgh and East of Scotland, Edinburgh; the Aberdeen and North of Scotland College of Agriculture, Aberdeen; the University College of North Wales, Bangor; the University College of Wales, Aberystwyth. Space unfortunately is not available for the production of these notes in their entirety, but most of the many useful lessons they afford to the farmer are incorporated in the different parts of the work dealing with the particular subjects to which the results specially relate.

THE SEASONS—WEATHER AND WORK.

The Agricultural Year.—The Agricultural Year practically begins immediately on the completion of the grain harvest, and the commencement of autumn wheat-sowing. And as this may be sooner or later, according to the lateness or earliness of the season, so the agricultural year may commence sooner or later in different years; just as it begins at different times in different climates when the seasons are normal. It may begin early in September in the south of England after an early harvest, or it may be postponed until near the end of November in less favoured districts when the harvest is very late. Here, however, we take the seasons in their natural sequence.

SPRING.

FIELD OPERATIONS AND SPRING WEATHER.

In the vegetable world winter is the season of repose, of passive existence, of dormancy, though not of death. Spring, on the contrary, is the season of returning life, of passing into active exertion, of hope, and of joy; of hope, as the world of life springs into view immediately after the industrious hand has scattered the seed upon the ground—and of joy, in contemplating with confidence the reproductions of the herds and flocks. It would be vain to attempt to describe the emotions to which this delightful season gives birth. It is better that the pupil of agriculture should enjoy the pleasure for himself; for "the chosen draught, of which every lover of nature may drink, can be had, in its freshness and purity, only at the living fountain of nature; and if we attempt to fetch it away in the clay pitchers of human description, it loses all its spirit, becomes insipid, and acquires an earthy taste from the clay."

Early Rising and the Joys of Spring.—To enjoy the beauties of spring in perfection, "it is necessary to take advantage of the morning, when the beams of the newly risen sun are nearly level with the surface of the earth; and this is the time when the morning birds are in their finest song, when the earth and the air are in their greatest freshness, and when all nature mingles in one common morning hymn of gratitude. There is something peculiarly arousing and strengthening, both to the body and the mind, in the early time of the morning; and were we always wise enough to avail ourselves of it, it is almost incredible with what ease and pleasure the labours of the most diligent life might be performed. When we take the day by the beginning, we can regulate the length of it according to our necessities; and whatever may be our professional avocations, we have time to perform them, to cultivate our minds, and to worship our Maker, without the one duty interfering with the other."[1]

Cares of Stock-owners in Spring.—Spring is the busiest of all seasons on the

[1] Mudie's *Spring*.

farm. The cattle-man, besides continuing his attendance on the feeding cattle, has now the more delicate task of waiting on the cows at calving, and providing comfortable lairs for new-dropped calves. The dairymaid commences her labours, not in the peculiar avocations of the dairy, but in rearing calves—the support of a future herd. The farrowing of pigs also claims a share of attention. The shepherd, too, has his painful watchings, day and night, on the lambing ewes; and his care of the tender lambs, until they are able to gambol upon the new grass, is a task of peculiar interest, and naturally leads to higher thoughts.

Field-work in Spring.—The condition of the fields demands attention as well as the reproduction of the stock. The day now affords as many hours for labour as are usually bestowed at any season in the field. The ploughmen, therefore, know no rest for at least ten hours every day, from the time the harrows are yoked for spring tillage until the turnips are sown. The turnip land, bared as the turnips are consumed by sheep, or removed to the steading, is now ploughed and prepared for spring wheat, barley, or oats — that is, should the weather be mild and the soil dry enough. The first sowing is the spring wheat; then the beans, the oats, and the barley. The fields intended for the root crops are then prepared. Grass seeds are then sown amongst the young autumnal wheat, as well as amongst the spring wheat and the barley or oats.

The hedger resumes his work of water-tabling and scouring ditches, cutting down and breasting old hedges, and taking care to fence with paling the young quicks upon the hedge-bank, which he may have planted during fresh weather in winter, as also to make gaw-cuts in the sowed fields.

The steward is now on the alert, urges the progress of every operation, and intrusts the sowing of the crops to none but himself, or a tried hand. Thus every class of labourers have their work appropriated for them at this busy season; and as the work of every one is carefully defined, it is scarcely possible for so great a mistake to be committed as that any piece of work should be neglected by all.

The Farmer's Duties in Spring.—The farmer himself now feels that he must be "up and doing." His mind becomes stored with plans for future execution; and in order to see them executed at the proper time and in the best manner, he must now forego all visits, and remain at home for the season; or at most undertake an occasional and hasty journey to the market town to dispose of surplus corn and transact other pressing business. The work of the fields now requiring constant attendance, his mind as well as body becomes fatigued, and, on taking the fireside after the labours of the day are over, the farmer seeks for rest and relaxation rather than mental toil. He should at this season pay particular attention to the state of the weather, by observing the barometric and thermometric changes, and make it a point to observe every external phenomenon that has a bearing upon the changes of the atmosphere, and be guided accordingly in giving his instructions to his people.

Weather in Spring.—The weather in spring, in the zone we inhabit, is exceedingly variable, alternating, at short intervals, from frost to thaw, from rain to snow, from sunshine to cloud—very different from the steady character of the arctic spring, in which the snow melts without rain, and the meads are covered with vernal flowers ere the last traces of winter have disappeared. Possessing this variability in its atmospherical phenomena, spring presents few having peculiarities of their own, unless we except the cold unwholesome east wind which prevails from March to May, and the very heavy falls of snow which occasionally occur in February.

Spring Winds.—All the seasons have their peculiar influence on the winds. The character of the winds in spring is, that they are very sharp when coming from the N. or N.E. direction; and they are also frequent, blowing strongly sometimes from the E. and sometimes from the W. In the E. they are piercing, even though not inclining to frost; in the W. they are strong, boisterous, squally, and rising at times into tremendous hurricanes, in which trees escape being uprooted only in consequence of their leafless state.

Snow in Spring.—Very frequently snow covers the ground for a time in spring. The severest snowstorms and falls usually occur in February. It is a serious affliction to the sheep-farmer when a severe and protracted snowstorm occurs in spring.

Rain in Spring.—The character of rain in spring is sudden, violent, and cold, not unfrequently attended with hail.

Evaporation in Spring.—Evaporation is quick in spring, especially with an E. wind, the surface of the ground being as easily dried as wetted. Thus two or three days of drought will raise the dust in March, and hence the cold felt on such occasions.

Birds in Spring Storms.—During a snowstorm in spring, wild birds, becoming almost famished, resort to the haunts of man. The robin is a constant visitor, and helps himself with confidence to the crumbs placed for his use. The male partridge calls in the evening within sight of the house, in hopes of obtaining some support before collecting his covey together for the night to rest upon the snow.

Rooks now make desperate attacks upon the stacks, and will soon force their way through the thatch. Beginning their operations at the top, they seem to be aware of the exact place where the corn can be most easily reached. Sparrows burrow in the thatch; and even the diminutive tomtit, with a strength and perseverance one should suppose beyond his ability, pulls out whole straws from the side of the stacks, to procure the grain in the ear.

Cottage Gardening.—"By the time the season is fairly confirmed, the leisure hours of the cottagers," and of the ploughmen, who are cottagers of the best description, are spent, in the evening, "in the pleasing labour, not unaccompanied with amusement, of trimming their little gardens, and getting in their early crops. There is no sort of village occupation which men, women, and children set about with greater glee and animation than this; for, independently of the hope of the produce, there is a pleasure to the simple and unsophisticated heart in 'seeing things grow,' which, perhaps, they who feel the most are least able to explain.

"Certain it is, however, that it would be highly desirable that not only every country labourer, but every artisan in towns, where these are not so large as to prevent the possibility of it, should have a little bit of garden, and should fulfil the duty which devolved on man in a state of innocence, 'to keep it and to dress it.'"

The Farmer's Garden. — Farmers, as a rule, are bad gardeners. Not unfrequently the garden, or where the garden should be, is one of the most thoroughly neglected spots on the farm. This is much to be regretted, for the value of a good, well-stocked kitchen-garden to a household is very great. There should be a garden on every farm, and it may be kept in good order at trifling expense. The hedger, stableman, or some other of the farm-servants, should know as much of the art of gardening as to be able to keep the farmer's garden in decent order in the absence of a gardener, whose assistance may with advantage be called in to crop the ground in the respective seasons. A field-worker now and then could keep the weeds in subjection, and allow both sun and air free access to the growing plants. Besides carelessness about the garden, the same feeling is evinced by too many farmers in the slovenly state in which the shrubbery and little avenue attached to their dwelling are kept.

Fat Cattle. — In spring the farmer thinks of disposing of the remainder of his fat cattle. Should he not be offered the price he considers them worth, he may keep them on for a time—a few of them perhaps for a month or two on grass—for beef is usually plentiful and cheap in spring, and scarce and dear early in summer.

Grass Parks.—Spring is the season for letting grass parks. In the majority of cases the parks are held by landed proprietors. The ready demand for old grass induces the retention of pleasure-grounds in permanent pasture, and removes temptation from a landlord to speculate in cattle. It is not customary for farmers to let grass parks, except in the neighbourhood of large towns, where cowfeeders and butchers find them so convenient as to induce them to tempt farmers with high prices. Facility of

obtaining grass parks in the country is useful to the farmer who raises grazing stock, when he can give them a better bite or warmer shelter than he can offer them himself, on the division of the farm which happens to be in grass at the time.

ADVANTAGES OF HAVING FIELD-WORK WELL ADVANCED.

The season — *early spring* — having arrived when the labouring and sowing of the land for the various crops cultivated on a farm of mixed husbandry are about to occupy all hands for several months to come, the injunction of old Tusser to undertake them in time, so that each may be finished in its proper season, should be regarded as sound advice. When field-labour is advanced ever so little at every opportunity of weather and leisure, no premature approach of the ensuing season can come unawares; and no delay beyond the usual period will find the farmer unprepared to proceed with the work. When work proceeds by degrees, there is time to do it effectually. If it is not so done, the farmer has himself to blame for not looking after it. When work is advancing by degrees, it should not be allowed to be done in a careless manner, but with due care and method, so as to impress the work-people with the importance of what they are doing. The advantage of doing even a little effectually is not to have it to do over again afterwards; and a small piece of work may be done as *well*, and in as short a time, in proportion, as a greater operation.

Keep the Plough going.—Even if only one man is kept constantly at the plough, he would turn over, in the course of a time considered short when looked back upon, an extent of ground almost incredible. He will turn over an imperial acre a-day—that is, 6 acres a-week, 24 acres in a month, and 72 acres in the course of the dark and short days of the winter quarter. All this he will accomplish on the supposition that he has been enabled to go at the plough every working day; but as that cannot probably happen in the winter quarter, suppose he turns over 50 acres in that time, these will still comprehend the whole extent of ground allotted to be worked by every pair of horses in the year. Thus a large proportion of a whole year's work is done in a single, and that the shortest, quarter of the year. Now, a week or two may quickly pass, in winter, in doing things which, in fact, amount to time being thrown away.

Instances of misdirected labour are too apt to be regarded as trifles *in winter;* but they occupy as much time as the most important work—and at a season, too, when every operation of the field is directly preparatory to others to be executed in a more busy season.

Neglected Work inefficiently done.—The state of the work should be a subject for the farmer's frequent consideration, whether or not it is as far advanced as it should be; and should he find the work to be backward, he consoles his unsatisfied mind that when the season for active work really arrives, the people will make up for the lost time. Mere delusion—for if work can be made up, so can *time*, the two being inseparable; and yet, how can lost time be made up, when it requires every moment of the year to fulfil its duties, and which is usually found too short in which to do everything as it *ought to be done?* The result will always be that the neglected work is done in an inefficient manner.

Subdivision of Farm-work.—Field-labour should be perseveringly advanced in winter, whenever practicable. Some consider it a good plan, for this purpose, to apportion certain ploughmen to different departments of labour —some to general work on the farm, some constantly at the plough, others frequently at the cart. When the elder men and old horses, or mares in foal, are appointed especially to plough, that most important of all operations will be well and perseveringly executed, while the young men and horses are best suited for carting when not at the plough. Thus the benefits of the subdivision of labour may be extended to farm operations.

Advancing Field-work.—It is right to give familiar examples of what is meant by the advantage of having field-labour advanced whenever practicable. The chief work in spring is to sow the ensuing crops. It should therefore be the study of the farmer in winter to ad-

vance the work for spring sowing. When the weather is favourable for sowing spring wheat, a portion of the land, cleared of turnips by the sheep, may perhaps be ploughed for wheat instead of barley. If beans are cultivated, let the ploughing suited to their growth be executed; and in whatever mode beans are cultivated, care should be taken in winter to have the land particularly dry, by a few additional gaw-cuts where necessary, or clearing out those already existing. Where common oats are to be sown, they being sown earlier than the other sorts, the lea intended for them should be ploughed first, and the land kept dry; so that the worst weather in spring may not find the land in an unprepared state. The land intended for potatoes, for turnips, or tares, or bare fallow, should be prepared in their respective order; and when every one of all these objects has been prepared for, and little to do till the burst of spring work arrives, both horses and men may enjoy a day's rest now and then, without any risk of throwing work back.

Spring Preliminaries.—But besides field operations, other matters require attention ere spring work comes. The implements required for spring work, great and small, have to be repaired,—the plough-irons new laid; the harrow-tines new laid, sharpened, and firmly fastened; the harness tight and strong; the sacks patched and darned, that no seed-corn be spilt upon the road; the seed-corn threshed, measured up, and sacked, and what may be last wanted put into the granary; the horses new shod, that no casting or breaking of a single shoe may throw a pair of horses out of work for even a single hour;—in short, to have everything ready to start for the work whenever the first notice of spring shall be heralded in the sky.

Evils of Procrastination.—But suppose all these things have been neglected until they are wanted—that the plough-irons and harrow-tines have to be laid and sharpened, when perhaps to-morrow they may be wanted in the field—a stack to be threshed for seed-corn or for horse's corn when the sowing of a field should be proceeded with; suppose that only a week's work has been lost, in winter, of a single pair of horses, 6 acres of land will have to be ploughed when they should have been sown,—that instead of having turnips in store for the cattle when the oat-seed is begun, the farmer is obliged to send part of the draughts to fetch turnips—which cannot then be stored—and the cattle will have to be supplied with them from the field during all the busy season.

In short, suppose that the season of incessant labour arrives and finds every one unprepared to go along with it, what must be the consequences? Every creature, man, woman, and beast, will then be toiled beyond endurance every day, not to *keep up* work, which is a lightsome task, but to *make up* work, which is a toilsome burden. Time was lost and idled away at a season considered of little value; thus exemplifying the maxim, that "procrastination is the thief of time"—and after all, the toil will be bestowed in vain, as it will be impossible to sow the crop *in due season*. Those implicated in procrastination may fancy this to be a highly coloured picture; but it is drawn from life.

SUMMER.

THE WEATHER.

As spring is the restoration of life to vegetation, and the season in which the works of the field are again in activity, so summer is the season of *progress* in vegetation and in the works of the field. This advancement involves no difference of practice, only impressing into its service many minor works for the first time, in assistance to the greater. Many of these minor operations being manual, and performed in the most agreeable season of the year, they are regarded with peculiar interest and delight by the light-hearted farm-workers.

Atmospherical Complications in Summer.—The atmospherical phenomena of summer are not only varied, but of a complicated character, difficult

of explanation, and apparently anomalous in occurrence. There is *dew*, with a great deposition of water, at a time when not a cloud is to be seen; there is a *thunderstorm*, which suddenly rages in the midst of a calm; and *hail*, which is the descent of ice and congealed snow, in the hottest days of the year.

Beneficial Influence of Dew.—The deposition of dew is a happy provision of nature. Often when the rainfall is insufficient, the wants of vegetation are supplied by dew. This is particularly the case in tropical regions where there may be little or no rain for months, and where, owing to the rapid radiation of heat at night, and the great evaporation of moisture from the soil into the surrounding atmosphere during the day, abundant dews are deposited.

Summer Rain.—The character of rain in summer is refreshing. Even in a rainy season, though we may feel displeased at being kept within doors on a summer day, we feel assured that it will in a great measure be absorbed by the varied mass of vegetation which is in constant activity during this season.

Light.—*Light* is a most important element in nature for the promotion of vegetation in summer. Its properties are most evidently manifested in this season, and have been shortly and forcibly enumerated by Lindley. "It is to the action of leaves," he observes,—"to the decomposition of their carbonic acid and of their water; to the separation of the aqueous particles of the sap from the solid parts that were dissolved in it; to the deposition thus effected of various earthy and other substances, either introduced into plants, as silex and metallic salts, or formed there, as vegetable alkaloids; to the extrication of nitrogen, and probably to other causes as yet unknown,—that the formation of the peculiar secretions of plants, of whatever kind, is owing. And this is brought about principally, if not exclusively, by the agency of *light*. Their green colour becomes intense, in proportion to their exposure to light within certain limits, and feeble, in proportion to their removal from it; till, in total and continued darkness, they are entirely destitute of green secretion, and become blanched and etiolated. The same result attends all their other secretions; timber, gum, sugar, acids, starch, oil, resins, odours, flavours, and all the numberless narcotic, acrid, aromatic, pungent, astringent, and other principles derived from the vegetable kingdom, are equally influenced, as to quantity and quality, by the amount of light to which the plants producing them have been exposed."[1]

The advantage that summer possesses over the other seasons as regards light is seen in its comparative duration in the respective months. Summer indeed enjoys more than double the light of winter, a half more than spring, and a third more than autumn. Thus—

In Winter,

November	has	8	hours	10	minutes of light a-day.
December	"	7	"	8	" "
January	"	7	"	44	" "
Making a mean of		7	"	41	" "

In Spring,

February	has	9	hours	30	minutes of light a-day.
March	"	11	"	49	" "
April	"	14	"	9	" "
Making a mean of		11	"	49	" "

In Summer,

May	has	16	hours	11	minutes of light a-day.
June	"	17	"	16	" "
July	"	16	"	45	" "
Making a mean of		16	"	44	" "

In Autumn,

August	has	14	hours	34	minutes of light a-day.
September	"	12	"	23	" "
October	"	10	"	17	" "
Making a mean of		12	"	25	" "

Besides its existence for a greater number of hours each day, light is of greater intensity in summer than in the other seasons, because it is then transmitted through the atmosphere at a higher angle.

SUMMARY OF SUMMER FARM-WORK.

Calendar and Agricultural Seasons.—Practical farmers know well that farm-work cannot be sharply divided in accord-

[1] Lindley's *Theo. Horti.*, 52.

ance with the months of the calendar. Indeed the farming seasons, as commonly understood, differ considerably from the calendar seasons. For instance, there are the autumn and spring seed-times, which stretch respectively into winter and summer.

Root Sowing.—Early in summer the land for the root crops is worked, cleaned, drilled, dunged, and sown. The culture of roots is a most important and busy occupation, employing much labour in singling and hoeing the plants for the greater part of the summer.

Fat Cattle.—Feeding cattle not to be put to grass are now got rid of as soon as the state of the markets warrants. There is usually a deficiency of fat cattle for disposal early in summer, the winter supply becoming exhausted before grass-fed animals are fit for slaughter. It is thus a good plan, when it can be carried out conveniently, to have a few fat beasts for sale early in summer.

Fat Sheep.—The fat sheep are also sold, except when desired to have their fleece, in which case they are kept until the weather becomes warm enough for clipping.

Repairing Fences.—Before stock is put on grass, the hedger should mend every gap in the hedges and stone walls, and have the gates of the grass fields in repair.

Grazing Stock.—Young cattle, sheep, and cows are put on pasture, to remain all summer. Cattle and sheep graze well together, cattle biting the grass high, while sheep follow with a lower bite. For the same reason, horses and cattle graze well together. Horses and sheep, biting low, are not suitable companions on pasture. Horses, besides, often annoy sheep. Many successful stock farmers say better results are got by grazing cattle and sheep alternately than together.

Horses.—Horses now live a sort of idle life. They escape from the thraldom of the stall-collar in the stable to the perfect liberty of the pasture-field, and there they do enjoy themselves. In the opinion of many farmers it is better for work-horses to have forage at the steading than to be grazed on the fields. The brood-mare brings forth her foal, and receives immunity from labour for a time.

Haymaking.—Haymaking is represented by poets as a labour accompanied with unalloyed pleasure. Lads and lasses are doubtless then as merry as chirping grasshoppers. But haymaking is in sober truth a labour of much toil and heat: wielding the hayrake and pitchfork in hot weather, for a livelong day, is no child's play.

Weaning Lambs.—The weaning of lambs from the ewes is now effected, and marks of age, sex, and ownership are stamped upon the flock.

Forage Crops.—The forage crops on farms in the neighbourhood of towns are now disposed of to cowfeeders and carters.

Dairying.—Butter and cheese are made on dairy-farms in quantities which the supplies of milk warrant.

Weeds.—Summer is the best of all seasons for making overwhelming attacks upon weeds, those spoilers of fields and contaminators of grain. Whether in pasture, on tilled ground, along drills of green crops, amongst growing corn, or in hedges, young and old, weeds should be day by day exterminated. And their extermination is, in many cases, most effectually accomplished by the minute and painstaking labour of field-workers; for which purpose they are provided with appropriate hand-implements.

Insect Attacks.—This is the season in which all manner of insects attack both crops and stock, much to their injury and annoyance. Reliable information for the combating of these plagues is provided in this work.

Top-dressing.—Top-dressings of specific manures upon growing crops are applied for the promotion of their growth and fecundity, at the fittest state of weather and crop.

Hours of Labour.—The hours of field-work in summer vary in different parts. In some parts it is the practice to go as early as four or five o'clock in the morning to the yoke, and the forenoon's work is over by nine or ten, time being given for rest in the heat of the day. The afternoon's yoking commences at one o'clock, and continues till six. Thus ten hours are spent in the fields. But in most parts of the country the morning yoking does not commence till six o'clock, and, on terminating at

eleven, only two hours are allowed for rest and dinner till one o'clock, when the afternoon's yoking begins, terminating at six P.M. In some places the afternoon yoking does not commence till two o'clock, and, finishing at six, only nine hours are spent in the fields; or it is continued till seven o'clock. In other parts, only four hours are spent in the morning yoking, when the horses are let loose at ten o'clock, and, on yoking again from two till six in the afternoon, only eight hours are devoted to work in the fields, the men being employed elsewhere by themselves for two hours.

Many farmers maintain that the best division of time is to yoke at five o'clock in the morning, loose at ten, yoke again at one, and loose at six in the evening, giving three hours of rest to men and horses at the height of the day, and ten hours of work in the field. One drawback to this plan is that, without their night's rest being unduly curtailed, the horses cannot have had time to feed sufficiently before the day's work begins.

Day-labourers and field-workers, when not working along with horses, often work from seven till twelve, and from one till six o'clock in the evening, having one hour for rest and dinner. When labourers take their dinner to the field, this is a convenient division of time; but when they have to go home to dinner, one hour is too little for dinner and rest between the yokings — and rest is absolutely necessary, as neither men nor women are able to work ten hours without an interval of more than one hour. It is a better arrangement for field-workers to go to work at six instead of seven, and stop at eleven instead of twelve.

When field-workers labour in connection with the teams, they must conform with their hours.

Rest.—The long hours of a summer day, of which at least ten are spent in the fields—the high temperature of the air, which suffuses the body with perspiration—and the oft-varying character of field-work in summer, bearing hard both on mental and physical energies, cause the labourer to seek rest at an early hour of the evening. None but those who have experienced the fatigue of working in the fields, in hot weather, for long hours, can sufficiently appreciate the luxury of rest—a luxury truthfully defined in these beautiful lines:—

"Night is the time for rest.
How sweet, when labours close,
To gather round the aching breast
The curtain of repose—
Stretch the tired limbs, and lay the head
Upon one's own delightful bed!"

JAMES MONTGOMERY.

The Farmer's Duties.—Every operation, at least early in summer, requires the constant attention of the farmer. Where natural agencies exert their most active influences on animal and vegetable creation, he requires to put forth his greatest energies to co-operate with the very rapid changes they produce. Should he have, besides his ordinary work, field experiments in hand, the demands upon his attention and time are the more urgent, and he must devote both assiduously if he expect to reap the greatest advantage derivable from experimental results.

The Farmer's Holiday. — Towards the end of summer is the only period in which the farmer has liberty to leave home without incurring the blame of neglecting his business. Even then the time he has to spare is very limited. Strictly speaking, he has only about two or three weeks before the commencement of harvest in which to have leisure for travel. A journey once a-year to witness the farm operations of other parts of the kingdom, or of foreign countries, enlightens him in many uncertain points of practice. He there sees mankind in various aspects, his mind becomes widened and raised above local prejudices, and a clearer understanding of places, manners, and customs is afforded him when reading the publications of the day. A month so spent may, in its experience, be worth a lease-length of local reading and of stay-at-home life.

AUTUMN.

AUTUMN WEATHER AND FIELD OPERATIONS.

Having passed through Spring and Summer, we now contemplate Autumn, the season of *fruition*, in which nature, bringing every plant to perfection, provides for the ensuing year sustenance for man and beast.

Rewards of Labour.—Autumn maturing its products, the toiling labours of the husbandman during the period of a year find their reward. In it, hope enjoys the possession of the thing hoped for; and the yield being plentiful, the husbandman is full of thankfulness. "It is this feeling which makes the principles of seasonal action thicken upon us as the year advances, and the autumn to become the harvest of knowledge as well as the fruits of the earth. Nor can one help admiring that bountiful and beautiful wisdom which has laid the elements of instruction most abundantly in the grand season of plenty and gratitude."

Rain in Autumn.—The greatest average quantity of rain falls in October. The heaviest rains come down in summer and early autumn months. In summer, over an inch will sometimes fall in a few hours in short and tempestuous torrents. In autumn the same quantity will occupy many hours in falling.

Autumn Work.

Harvest.—The great work of autumn is the harvesting of the corn crops. This necessarily engrosses most of the time and attention of the farmer and his assistants until these perishable crops are secured beyond danger in the stack-yard.

Weather and Harvest.—During this eventful period of a month at least, the farmer looks night and day at "the face of the sky," consults his glass, and fear or hope inspires him according to its indications. And no wonder, for the results of a whole year of labour are at stake on the exigency of the weather, and he feels that unless he exercise his best skill and judgment he will not be satisfied with himself.

Magnitude of Harvest-work.—The labour of harvesting a crop is almost incredible. Only conceive the entire cereal crop of such a nation as this reaped, carried, and stored in minute sheaves, in the short period of a few weeks! Then, besides the harvest of the cereal plants, the leguminous as well as portions of the root crops are stored in autumn.

Autumn Anomalies.—Some curious anomalies in farm labour occur in autumn. One is sowing a new crop of wheat, while the matured one of the same grain is being reaped; another, that while spring is the natural season for the reproduction of animals, autumn is that for the reproduction of sheep.

Field-sports.—The sports of the field commence in August. The gatherings on the hills in thousands on the historic "Twelfth" of August, in quest of the unique-flavoured red grouse (*Lagopus scoticus*), find a welcome home in shielings, which, at other seasons, would be contemned by their luxurious urban occupiers. Partridge-shooting comes in September, at times before the corn is cut down. Hare-hunting finds ample room by October. Last of all, the attractive "music" of the pack gathers around it, from hill and dale, all the active Nimrods of the country. At this season, however, most farmers are too much occupied in their important work to bestow time on field-sports.

Autumn Cultivation.—Autumn cultivation should be assiduously practised where the stubbles are in need of cleaning, when the weather immediately after harvest is dry and favourable. The weeds are then easier to destroy, and a little of this work in autumn saves an enormous amount of labour in spring, besides giving a great set forward to the agricultural work of the year. But autumn cultivation for the mere purpose of exposing an upturned furrow to the action of winter frosts cannot in all cases be accounted good husbandry. To preserve the soil fertility during the period of winter rains, the soil must be covered with a growing crop of some kind.

Autumn Crops.—Several crops sown in autumn succeed in England, but few can be sown in Scotland at that season with safety. Most of the forage plants sown in autumn in England, for affording early food in spring — as crimson clover, winter tares, &c.—would not withstand a Scottish winter; and some plants sown in England on stubble-ground—as the stone turnip and rape—could not with advantage be sown so late in Scotland.

The harvest in England is from two to three weeks earlier, the stubble is bare so much earlier, and the land is in a comparatively drier state, and may be worked to advantage before the wet weather sets in at the latter part of autumn. The later harvest in Scotland, and the earlier winter, would not, as a rule, permit working stubble after a grain crop; and there is but little done in Scotland in the way of growing winter forage crops.

WINTER.

THE WEATHER, AND FIELD OPERATIONS IN WINTER.

Work in the Steading.—The subjects which court attention in winter are of the most interesting description to the farmer. He directs his attention largely to work conducted in the steading, where the cattle and horses are collected, and this with the preparation of the grain for market affords pleasant employment within doors. The progress of live stock towards maturity is always a prominent object of the farmer's solicitude, and especially so in winter, when they are comfortably housed in the farm-steading, plentifully supplied with wholesome food, and so arranged in various classes, according to age and sex, as to be easily inspected at any time.

Field Work.—The labours of the field in winter are confined to a few great operations. These are chiefly ploughing the soil in preparation for future crops, and supplying food to live stock. The commencement of the ploughing for the year consists in turning over the ground which had borne a part of the grain crops, and which now bears their *stubble* —which is just the portion of the straw of the previous crops left uncut.

Water-channels in Ploughed Land.—The stubble land ploughed in the early part of winter, in each field in succession, is protected from injury from stagnant rain-water by cutting channels with the spade through hollow places, permitting the rain to run quickly off into the ditches, and leaving the soil in a dry state until spring.

Ploughing Lea.—Towards the latter part of winter the grass land, or *lea*, intended to bear a crop in spring, is ploughed; the oldest grass land being earliest ploughed, that its toughness may have time to be softened before spring, by exposure to the atmosphere. The latest ploughed is the youngest grass.

Best Season for Draining.—When the soil is naturally damp underneath, winter is selected for removing the water by draining. It is questioned by some farmers whether winter is the best season for draining, as the usually rainy and otherwise unsettled state of the weather renders the carriage of the requisite materials on the land too laborious. By others it is maintained that, as the quantity of water to be drained from the soil determines both the number and size of the drains, these are best ascertained in winter; and as the fields are then entirely free of crop, that season is the most convenient for draining. Truth may not absolutely acquiesce in either of these reasons, but, as a rule, draining may be successfully pursued at all seasons.

Planting Hedges.—Where fields are unenclosed, and are to be fenced with a quick thorn-hedge, winter is the season for performing the work. Hard frost, a fall of snow, or heavy rain, may put a stop to the work for a time, but in all other states of the weather it may be proceeded with in safety.

Water-meadows.—When water-meadows exist on a farm, winter is the season for carrying on the irrigation with water, that the fostered grass may be ready to be mown in the early part of

the ensuing summer. It is a fact worth bearing in mind that *winter* irrigation produces more wholesome herbage for stock than summer irrigation. On the other hand, summer is the most proper season for forming water-meadows.

Feeding Stock.—The feeding of stock is so large and important a branch of farm business in winter, that *it* regulates the time for prosecuting several other operations. It determines the quantity of turnips that should be carried from the field in a given time, and causes the prudent farmer to take advantage of dry fresh days to store up a reserve for use in any storm that may ensue. All the cattle in the farmstead in winter are placed under the care of the *cattleman.*

Threshing Grain. — The necessities of stock-feeding also determine the quantity of straw that should be provided from time to time; and upon this, again, depends largely the supply of grain that may be sent to market at any time. For although it is in the farmer's power to thresh as many stacks as he pleases at one time, and he may be tempted to do so when prices are high; yet, as new threshed straw is better than old, both as litter and fodder, its threshing usually depends to some extent on the wants of the stock.

Sheep on Turnips.—The feeding of sheep on turnips, in the field, is practised in winter. When put on turnips early in winter, sheep consuming only a proportion of the crop, a favourable opportunity occurs for storing the remaining portion for cattle in case of bad weather. The proportion of turnips used by cattle and sheep determines the quantity that should be taken from the field.

Attention to Ewes.—Ewes roaming at large over pastures require attention in winter in frost and snow, when they should be supplied with clover-hay, or with turnips when hay is scarce.

Marketing Grain.—The preparation of grain for sale is an important branch of winter farm business, and should be strictly superintended. A considerable proportion of the labour of horses and men is occupied in carrying grain to the market town or railway station—a species of work which used to jade farm-horses very much in bad weather, but railways have materially shortened the journeys of horses in winter.

Carting Manure.—In hard frost, when the plough is laid to rest, or the ground covered with snow, and as soon as

> "By frequent hoof and wheel, the roads
> A beaten path afford,"

farmyard manure is carried from the courts, and placed in large heaps on convenient spots near or on the fields which are to be manured in the ensuing spring. This work is continued as long as there is manure to carry away, or the weather is suitable.

Implements used in Winter.—Of the implements of husbandry, only a few are used in winter: the plough is constantly so when the weather will permit; the threshing-machine enjoys no sinecure; and the cart finds frequent and periodic employment. Most of the other implements are laid by for the winter.

Winter Recreation. — *Field-sports* have their full sway in winter, when the fields, bared of crop and stock, sustain little injury by being traversed. Although farmers bestow but a small portion of their time on field-sports—and many have no inclination for them at all—they might harmlessly enjoy these recreations at times. When duly qualified, why should not farmers join in a run with fox-hounds?—or take a cast over the fields with a pointer?—or shout a see-ho to greyhounds? Should frost and snow prevent the pursuit of these sports, curling and skating afford healthful exercise both to body and mind.

Winter Hospitality.—Winter is the season for country people reciprocating the kindnesses of hospitality, and participating in the amusements of society. The farmer delights to send the best produce of his poultry-yard as Christmas presents to his friends in town, and in return to be invited into town to partake of its amusements. But there is no want of hospitality nearer home. Country people maintain intercourse with each other; while the annual county ball in the market-town, or an occasional one for charity, affords a seasonable treat; and the winter is often wound up by a meeting given by the Hunt to those who had shared in the sport during the hunting season.

Domestic Enjoyment. — Winter is the season of *domestic enjoyment.* The fatigues of the long summer day leave little leisure, and less inclination, to tax the mind with study; but the long winter evening, after a day of bracing exercise, affords a favourable opportunity for conversation, quiet reading, or music. In short, there is no class more capable of enjoying a winter's evening in a rational manner than the family of the country gentleman or of the farmer.

Weather in Winter.—The *weather* in winter, being very precarious, is a subject of intense interest, and puts the farmer's skill to anticipate its changes severely to the test. Seeing that every operation of the farm is to some extent dependent on weather, a familiar acquaintance with local prognostics which indicate a change for better or worse becomes a duty. In actual rain, snow, or hard frost, few outdoor occupations can be executed; but if the farmer have wisely "discerned the face of the sky," he may arrange his operations to continue for a length of time, if the storm is to endure—or be left in safety, should the strife of the elements quickly cease.

Winter Rain. — The character of *winter rain* has more of cold and discomfort than of quantity. When frost suddenly gives way in the morning about sunrise, rain may be looked for during the day. If it do not fall, a heavy cloudiness will continue all day, unless the wind change, when the sky may clear up. If a few drops of rain fall before mid-day after the frost has gone, and then ceases, a fair and most likely a fine day will ensue, with a pleasant breeze from the N. or W., or even E. When the moon shines brightly on very wet ground, the shadows of objects become very black, which is a sign of continuance of rain and unsettled state of the wind. Rain often falls with a rising barometer, which is usually followed by fine healthy weather, attended with feelings that indicate a strong positive state of electricity.

Cold and Frost.—*Frost* has been represented to exist only in the absence of heat; but, more than this, it also implies an absence of moisture.

The most intense frost in this country rarely penetrates more than one foot into the ground, on account of the excessive dryness occasioned by the frost itself withdrawing the moisture.

Beneficial Influence of Frost.—Frost is a useful assistant to the farmer in pulverising the ground, and rendering the upper portion of the ploughed soil favourable to the vegetation of seeds. It acts in a mechanical manner on the soil, by freezing the moisture in it into ice, which, on expanding at the moment of its formation, disintegrates the indurated clods into fine tilth. Frost always produces a powerful evaporation of the pulverised soil, and renders it very dry on the surface; by the affinity of the soil for moisture putting its capillary power into action, the moisture from the lower part of the arable soil, or even from the subsoil, is drawn up to the surface and evaporated, and the whole soil is thus rendered dry. Hence, after a frosty winter, it is possible to have the ground in so fine and dry a state as to permit the sowing of spring wheat and beans, in the finest order, early in spring.

Plants uprooted by Frost.—On lands already planted, however, the effect of frost is not always so desirable, especially where the soil is at all wet or the drainage defective. Examine such a field in early spring and it will be found that many plants have been thrown out of the ground during the winter, or have their roots partially exposed. Wheat, grass, strawberry, and other plants are particularly liable to this summary ejectment, and considerable loss and disappointment are often sustained in farms and gardens from this cause. This uprooting of plants by frost only occurs where the soil is saturated with moisture. In each case the first act of frost is to solidify the surface layer. In doing this, the plants growing thereon are firmly caught and secured by the neck. If the frost continues, it next freezes the subjacent stratum, by virtue of the water it contains, which must enlarge, and consequently bear up on its shoulders the surface layer. Thus those plants which were secured to the surface more strongly than their roots adhered to the frozen soil below will be raised up, and to a certain extent eradicated, and when

the thaw comes and the soil subsides, these plants are thrown out altogether.

Snow.—Rain falls at all seasons, but *snow* only in winter, or late in autumn, and early in spring. Snow is just frozen rain, so that whenever symptoms of rain occur, snow may be expected if the temperature of the air is sufficiently low to freeze vapour. Vapour is supposed to be frozen into snow at the moment it is collapsing into drops to form rain, for clouds of snow cannot float about the atmosphere any more than clouds of rain.

Snow keeps Land warm.—During the descent of snow the *thermometer sometimes rises*, and the *barometer usually falls*. Snow has the effect of retaining the temperature of the ground at what it was when snow fell. It is this property which maintains the warmer temperature of the ground, and sustains the life of plants during the severe rigours of winter in the arctic regions, where the snow falls suddenly after the warmth of summer; and it is the same property which supplies water to rivers in winter, from under the perpetual snows of the alpine mountains. "While air, above snow, may be 70° below the freezing-point, the ground below the snow is only at 32°."[1] Hence the fine healthy green colour of young wheat and grass after the snow has melted in spring.

Snow-water and Rain.—In melting, 27 inches of snow give 3 inches of water. Rain and snow-water are the *softest* natural waters for domestic purposes, and are also the purest that can be obtained from natural sources, provided they are caught before reaching the ground. Nevertheless, they are impregnated with oxygen, nitrogen, and carbonic acid, especially with oxygen; and rain-water and dew contain nearly as much air as they can absorb.

Uses and Drawbacks of Snow.—Snow renders important services to husbandry. If it fall shortly after a confirmed frost, it acts as a protective covering against its further cooling effects on soil, and in this way protects the young wheat and clover from destruction by intense frosts. On the other hand, frost and rain and snow may all retard the operations of the fields in winter very materially, by rendering ploughing and the cartage of turnips impracticable. Heavy snow-storms are also very detrimental to the interests of sheep-farmers.

Hoar-frost. — *Hoar-frost* is not always frozen dew, for dew is sometimes frozen in spring into globules of ice which do not at all resemble hoar-frost, which is beautifully and as regularly crystallised as snow. The formation of hoar-frost is always attended with a considerable degree of cold, because it is preceded by great radiation of heat and vapour from the earth, and the phenomenon is the more perfect the warmer the day and clearer the night. In the country, hoar-frost is of most frequent occurrence in autumn and winter, in such places as have little snow or continued frost.

In general, low and flat lands in the bottoms of valleys, and grounds that are land-locked hollows, suffer most from hoar-frost, while all sloping lands and open uplands escape injury. But it is not their relative elevation above the sea, independently of the freedom of their exposure, that is the source of safety to the uplands; for if they are enclosed by higher lands, without any wide open descent from them on one side or another, they suffer more than similar lands of lesser altitude.

Injury by Hoar-frost.—The severity of the injury by hoar-frost is much influenced by the wetness of the soil at the place; and this is exemplified in potatoes growing on haugh-lands by the sides of rivers. These lands are generally dry, but bars of clay sometimes intersect them, over which the land is comparatively damp. Hoar-frost will affect the crop growing upon these bars of clay, while that on the dry soil will escape injury; and the explanation of this is quite easy. The temperature of the damp land is lower than that of the dry, and on a diminution of the temperature during frost it sooner gets down to the freezing-point, as it has less to diminish before reaching it. Young potato-plants are exceedingly susceptible of being blackened by hoar-frost.

[1] Phillips's *Facts*, 440.

SEEDS OF THE FARM AND THEIR IDENTIFICATION.*

PART I.—GENERAL.

When examining farm seeds for purposes of identification the main points to be attended to are—

1. The nature of the seed. 2. Its size. 3. Its form and surface. 4. Its colour and gloss. 5. The impurities present. 6. Adulterants. 7. Parasites.

The Nature of Farm Seeds.—Under the name "seed" the farmer includes anything and everything which he sows to produce a crop. Sometimes this "seed" is a *tuber*, as for potato; sometimes the *whole spikelet* of a grass, as for meadow foxtail; sometimes only a *detached part of the spikelet*, as for oats and barley among the cereals, for rye-grasses, meadow-grass, cocksfoot, &c., among the forage grasses; sometimes *a grain* (fruit), as, for example, wheat and rye, shelled timothy and shelled cocksfoot; sometimes *a part split off from a fruit*, and composed of a seed enclosed in a case, as for carrot and parsnip; and only sometimes the *real seed*, as for turnips and clovers. Occasionally, indeed, the part sown as seed is a whole cluster of fruits grown together into one body,—for example, mangel. The habit of calling things so various in their nature by the one name "seed" makes us only too ready to think that they really are seeds: we judge as if they were, and often pronounce them good or bad from the mere appearance of the coat.

Whenever we try to distinguish and identify, the very first thing to be done is to consider the component parts of the "seed," and this with the view of determining the real nature of the thing, and so of deciding the class of "seed" with which we are dealing.

* *The illustrations of seeds given in this section are reproduced by kind permission from an excellent series of photo-micrographs prepared by Messrs James Hunter, Limited, Seedsmen, Chester. The illustrations are the property of that firm, and may not be reproduced. The seeds in Figures* 363 *and* 374 *are magnified* 4½ *diameters; those in Figures* 371, 382, 387, 389, 394, 395, *and* 398, 10 *diameters; and the seeds in the other Figures* 6 *diameters.*

The Size of Seeds. — To determine the size of a seed is a very simple matter. We require for the purpose a sheet of paper ruled off into squares of one millimetre. A large sheet of such *millimetre paper* can be purchased for a few pence. We sprinkle a few seeds over the sheet and read off their size by the aid of the squares on the paper. If we use a pocket lens the size can easily be read to one quarter of a millimetre. When we are measuring a mangel seed, for example, we must remember that it is not the true seed we are measuring, but really the box that contains the seeds. In this case we are liable to think that the seed is a large one, but we must carefully notice that the *true seed* within the box is quite small, and when planted in the ground behaves as a small seed.

Form and Surface of "Seeds."—Certain forms are very characteristic. All common seeds of the chickweed family, for example, are approximately *kidney-shaped*, with small peg-like projections (tubercles) on the surface. Again, certain seeds are *globular*, and readily roll about on a sheet of paper; such are the common cruciferous seeds and the "seeds" of timothy. Other "seeds" are marked by excessive *flatness*. Some of these flat seeds have a beak-like projection from one side of the apex (buttercups); some others a projection from the centre of the apex (red-shanks or persicarias). Seeds such as rib-grass are *two-faced;* others, such as docks and sorrels, *three-faced.* Burnet has *four wing-like projections*, and so on. Details of surface, such as the honeycomb depressions on geranium seed, the tiny appendage at the narrow end of pansy seed, and so forth, are best seen by the aid of a pocket lens.

Examination of Seeds by Microscope and by Pocket Lens. — The microscopic examination is a very simple matter if we go about it properly. We require a compound microscope with a very low power, say a 2-inch objective, and an instrument perfect for such a purpose can be purchased for less than

£2. A suitable holder for the seeds to be examined is an ordinary match-box half filled with paraffin wax instead of matches. We soften the surface of the wax by heat, and sprinkle a few seeds upon the melted surface. In a minute or so the wax hardens and holds the seeds fast in various positions. We now examine the seeds under the microscope, and note the form and any peculiarities presented by the surface. Another match-box with a strip of millimetre paper pasted over the bottom enables us to determine sizes with accuracy sufficient for purposes of identification. Very small seeds, as poas, dodder, and clover-rape, require such microscopic examination for satisfactory determination. For most farm seeds, however, a pocket lens, which need not cost more than a sixpence, is all that is necessary.

Colour and Gloss.—Colour is best determined by examination of a bulk sample: for details the seeds should be spread out on a sheet of paper and examined by a pocket lens. Natural gloss on the surface of such seeds as clovers is an important indication of freshness: artificial gloss, however, which is imparted by oil to certain brands of "Welsh clovers," indicates age rather than freshness.

Impurities in Farm Seeds.—Taken generally, a sample of commercial seed is composed of the following classes of ingredients:—

1. Mature seeds true to kind, some capable of germinating, some incapable.
2. Immature seeds and husks true to kind.
3. Seeds of other plants.
4. Dust, stones, pieces of straw, &c.

Suppose we have a cocksfoot sample containing 50 per cent mature seeds and 50 per cent husks of cocksfoot, and nothing else, what is the purity of such a sample? At first, one might say that the sample is pure; if, however, we consider that the germinating test does not apply to the empty husks, but only to those seeds that contain kernels, it is found better to agree to class the empty husks as impurity, and to say that the purity of such a sample is 50 per cent, thus regarding *all the chaff and husks as impurity*. We see, then, that impurities may vary in their nature: some are immature seeds and husks, some are seeds of weed-plants, and some others are mere uncleanness.

It is not enough, therefore, to determine the amount of impurity by weight: the point of greatest import is the nature of the impurity and the effect consequent upon sowing it into our land. This nature is the very point which rises into prominence whenever we begin seriously to discriminate our seeds.

Suppose, for example, we seed our land with rye-grass seed containing Yorkshire fog. At hay-cutting the Yorkshire fog is partly ripe, the rye-grass unripe. The consequence is that the land is left foul with seed shed from the Yorkshire fog. On the hay-loft floor, too, further seeds of the same Yorkshire fog will form much of the sweepings, and these, if they get into the dung, will contaminate other fields. Turn now to the rye-grass field in pasture and see what is happening there. The stock depastures the rye-grass, but leaves the Yorkshire fog comparatively untouched. The weeds are thus allowed to bloom and seed freely, and as the rye-grass dies out the white uneaten grass takes its place, and a field chiefly composed of Yorkshire fog results. To avoid such dangerous consequences the seed used should be free from dangerous weeds.

Adulteration and Deterioration.—Sometimes samples of seed are sold containing impurities which cannot have been *naturally* present—that is to say, seeds of inferior value have been *intentionally* added: such additions are adulterants. Examples of adulteration are:—

1. Substitution of perennial rye-grass for meadow fescue.
2. Substitution of New Zealand tall fescue for Rhenish tall fescue.
3. Substitution of wavy hair-grass for golden oat-grass.
4. Substitution of slender foxtail and Yorkshire fog for meadow foxtail.

These cases of adulteration are easily detected by any one who is familiar with the genuine seeds, and with those points which distinguish them from their adulterants.

Sometimes a variety from one locality is sold as from another locality. Seed sold as Scottish timothy, for example,

may not have been grown in Scotland at all. In the same way Chilian red clover may be substituted for English red, home Italian ryegrass for foreign, and so on.

Again, improved varieties are sometimes replaced by inferior strains, as in turnips. Although such deceptions are of the utmost importance, from a profit and loss point of view, it is often the case that no amount of skill in examining the seeds is of avail as a preventive. Sometimes, however, when the country in which the seed was grown is in dispute, it is possible to settle the point approximately by examining the weed seeds present, and noting to what country the weeds present naturally belong. Actual growth of the seeds on the land, too, may sometimes throw light on such deceptions; but there are often difficulties in bringing the deceptions home, even though the crop has been grown, since selected varieties are very liable to undergo change and deterioration under certain conditions of season and environment.

Parasites.—These are important, not from their amount but from their nature, their power of communicating disease to our crop, of spreading it from plant to plant, and of continuing it from year to year. Examples of such dangerous parasites are dodder in clover seeds, clover-rape in clover seeds, ergot in timothy, smut in corn, and bunt in wheat. Seeds free from such parasites should alone be sown.

PART II.—SPECIAL.

Classification of Farm Seeds.—For purposes of identification the common seeds of the farm, including their impurities, adulterants, and parasites, may be classified and arranged as follows:—

Class I. True Seeds.

The globular-seeded cruciferous plants.—1. Cabbage. 2. Swede. 3. Turnip. 4. Rape. 5. Mustard. 6. Charlock. 7. Runch. (P. 73.)

The kidney-shaped seeds of the chickweed family.—8. Corncockle. 9. Campion. 10. Chickweed. (P. 73.)

Leguminous seeds.—11. Red clover, its impurities and parasites. 12. Alsike and its impurities. 13. White clover and its impurities. 14. Yellow suckling clover. 15. Lucerne and its adulterants. 16. Trefoil and its fruit. 17. Bird's-foot trefoil and its adulterants. 18. Kidney vetch. (P. 74.)

Rib-grass seeds.—19. Rib-grass. 20. Greater rib-grass or way-bread. (P. 77.)

Class II. Fruits.

The flat buttercup "seeds."—21. Upright buttercup. 22. Creeping buttercup. (P. 77.)

The three-faced "seeds" of the dock family.—23. Buckwheat. 24. Dock. 25. Sheep's sorrel. (P. 78.)

The flat and beaked "seeds" of the dock family.—26. Persicaria or redshank. (P. 78.)

"Seeds" of composites.—27. Yarrow. 28. Ox-eye daisy. 29. Field chamomile. 30. Cornflower. 31. Field thistle. 32. Chicory. 33. Dandelion. 34. Nipplewort. (P. 79.)

Class III. Mericarps.

Umbelliferous "seeds."—35. Parsnip. 36. Parsley. 37. Carrot. (P. 80.)

"Seeds" of the Cleavers family (*Rubiaceæ*).—38. Sherardia. 39. Cleavers. (P. 81.)

Class IV. Nutlets.

40. Self-heal. 41. Myosotis. (P. 81.)

Class V. Multiple Fruits.

42. Mangel. (P. 82.)

Class VI. Grass "Seeds."

The whole spikelet.—43. Meadow foxtail. 44. Slender foxtail. 45. Yorkshire fog. (P. 82.)

The whole spikelet except the chaff (glumes).—46. Tall oat-grass or French rye-grass. 47. Timothy. (P. 84.)

Portion of spikelet with stalk on upper face (back rounded).—48. Italian ryegrass. 49. Perennial rye-grass. 50. Meadow fescue. 51. Rhenish tall fescue. 52. New Zealand tall fescue. 53*a*. Sheep's fescue. 53*b*. Hard fescue. 54. Crested dogstail. 55. Fescue hair-grass or hair-grass. 56. Soft brome. 57. Rye brome. (P. 85.)

Portion of spikelet—back V-shaped (keeled).—58. Cocksfoot. 59. Poas. 60. Purple molinia. (P. 87.)

Portion of spikelet — back or base awned. — 61. Golden oat. 62. Wavy hair-grass. 63. Tufted hair-grass. (P. 88.)

Class VII. Seeds of Parasites.

64. Clover-dodder. 65. Clover-rape. 66. Ergot of timothy. (P. 89.)

CLASS I.—TRUE SEEDS.

In all plants with no exception the true seed is a body containing an embryo plant in its interior. Such a seed is always formed in a flower from an ovule by a process of fertilisation and ripening. This ovule in all the classes of farm plants is always formed and ripened within a closed case, and to have *true seed* this case must have been removed so as to leave the seed bare and detached from the enclosing parts.

THE GLOBULAR-SEEDED CRUCIFEROUS PLANTS.

The seed here is always a true seed, composed of an embryo plant so doubled up as to form a tiny sphere, which is completely enclosed within a seed-skin. The crops grown from such seeds are: Cabbage, swede, turnip, rape, and mustard. A common cruciferous weed, with globular seeds, is the well-known charlock.

The taste of the seed-contents becomes important when identification is the object. Ground mustard-seeds, for example, when mixed with water, become the well-known condiment mustard, with its pungent taste and odour. Ground turnip-seeds, if mixed with water, would have no pungency whatever, but only taste. Instead of mustard-oil, we have here the *sweet-oil* of commerce. The oily-tasting seeds are: Cabbage, swede, turnip, and rape; while mustards and mustard-seeds, such as charlock, can produce the pungent taste and odour of mustard-oil.

1. *Cabbage.*

The seed is dark-brown, with a greyish tinge, suggesting mouldiness. The size depends upon the variety, and varies between 1¼ and 2¾ millimetres.

2. *Swede.*

The seed is dark-purplish-brown. The size ranges from 2 to 2¼ mm.

3. *Turnip.*

The seed is very like that of the swede, but generally slightly paler in tint.

4. *Rapes.*

Rapes are non-bulbing varieties of swede and turnip. The seed is accordingly like that of the swede or like that of the turnip, but it affords no indication of the bulbing or non-bulbing character of the plant which it can produce.

5. *Mustards.*

There are two species of mustard—the black, with black-skinned seeds, and the white, with white-skinned seeds. The dimensions of the black seeds range from 1 to 1½ mm., those of the white from 2 to 2¼ mm. The seeds are distinguished from those of turnip and swede by their pungent taste when chewed.

6. *Charlock.*

The seeds of charlock and of turnip are practically the same in size, but the former are slightly darker in colour. Charlock is rightly called a mustard weed, for when the seeds are chewed mustard-oil forms; thus by the taste distinction is easy.

7. *Runch.*

(Although considered here for convenience, runch "seed" really belongs to Class III.)

Runch is another mustard weed, whose seeds can yield mustard-oil. Here, however, the "seed" is not only a true seed, but a seed completely enclosed in a case that looks like a harmless little piece of fine-ribbed straw. When this seed-case is cut open, the true seed is seen to be a light-brown globose body about 3 mm. long and 2 mm. broad.

THE KIDNEY-SHAPED SEEDS OF THE CHICKWEED FAMILY.

The seeds of the whole chickweed family are always true seeds, as a rule kidney-shaped, and having a skin with minute but well-marked pig-like projec-

tions. When cut into, *snow-white starchy contents* are conspicuous next the concavity, and a curved embryo is seen lying upon the white substance within the convex part of the skin. Many members of this family occur as impurities in farm seeds, the most frequent being the poisonous-seeded corncockle in wheat; campions, and common chickweed (*Stellaria media*), in grasses and clovers.

8. *Corncockle.*

The seed is specially large for this family—namely, 3 × 2½ mm. in typical seeds. The seed-skin is very dark, almost black, with distinct projections on its surface. The kidney-shape is irregular, for one end of the seed is narrow and beak-like instead of rounded off.

9. *White Campion* (fig. 347).

The seeds are grey and kidney-shaped, 2 × 1½ mm. The surface of the seed-skin has distinct projections arranged in curved lines.

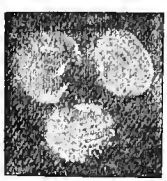


Fig. 347.—White campion (*Lychnis vespertina*).

Fig. 348.—Chickweed (*Stellaria media*).

10. *Common Chickweed* (fig. 348).

This is a small-seeded form, 1 mm. × 1 mm. These dimensions show that the kidney form is very much rounded, the length and breadth being almost equal. The skin is yellowish-brown, becoming darker with age, and has the usual pig-like projections.

LEGUMINOUS SEEDS.

The seed of a leguminous plant is, in all the cases here dealt with, a true seed, composed of a seed-skin filled up with an embryo plant. For purposes of distinction, it is important to notice that the embryo is always doubled up in such a way that its radicle—the part whose tip becomes the root—lies along the edge of the cotyledons, the first leaves of the plant. Thus is caused a ridge, very visible on the outside of the seed. The length, the thickness, the spread, and other characters of this external ridge correspond to the peculiarities of the radicle within, and such characters readily mark off the seed of one leguminous plant from the seed of another.

In the case of clover-seeds, and, indeed, in leguminous seeds generally, there is often a lack of swelling power, due to a peculiarity of the seed-coat. The outer cells of the coat are waterproof, from a glossy impregnation with silica and lime compounds. Such seeds are termed *hard.* All that is necessary to remedy this defect, and to allow the water to enter freely, is a mere scratch on the surface of the seed-skin. Accordingly, to improve the germinating power of commercial clover-seeds, they are sometimes shaken up in bags with sharp sand, and sometimes rolled about in specially constructed cylinders with a rough lining.

The clovers here considered are red, alsike, white, and yellow suckling. The other forage seeds noticed are lucerne, trefoil, bird's-foot trefoil, and kidney vetch.

11. *Red Clover* (fig. 349).

The seed varies in length from 1½ to 2¼ mm. The shape is oval, with a stout, blunt-pointed, projecting ridge a little more than half the length of the seed. The glossy surface of the skin is coloured rich purple at the broad end with the ridge, and fleshy or yellowish at the narrower end. Unripe seeds are

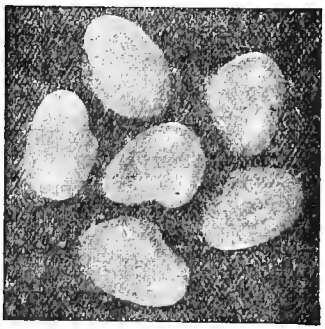


Fig. 349.—Perennial red clover (*Trifolium pratense perenne*).

The seeds illustrated on this page are magnified six diameters.

yellow all over, or of a greenish tinge. When the seed is old it loses its gloss, and the purple changes to a redder tint.

Sometimes the sample contains red clover fruit, composed of a thin seed-case with a rod-like projection from the apex, and one seed within. This seed-case readily opens in a transverse direction, and then the characteristic red clover-seed within is laid bare.

Common impurities are—

a. True seeds.—Campion (No. 9), rib-grass (No. 19), the commonest of all, and cut-leaved geranium.

b. Three-sided fruits of the Dock family. — Dock (No. 24) and sheep's sorrel (No. 25).

c. Composite fruits.—Ox-eye daisy (No. 28), field chamomile (No. 29), and nipplewort (No. 34).

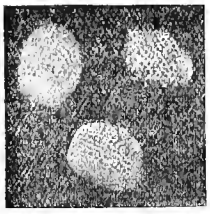


Fig. 350.—Cut-leaved geranium (*Geranium dissectum*).

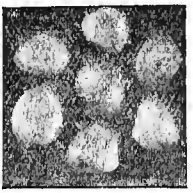


Fig. 351.—Alsike clover (*Trifolium hybridum*).

d. Cut-leaved Geranium.—The broad oval seed 2 × 1½ mm. is slightly flattened at the broad end, and of a purplish-brown colour. The most characteristic feature is the *honeycomb appearance of the skin*, readily seen with the naked eye (fig. 350).

e. Seeds of Parasites.—Clover-dodder (No. 64) and clover-rape (No. 65).

12. *Alsike Clover* (fig. 351).

The seed is small—from 1 to 1¼ mm. long—with a glossy, mottled, dark-olive skin. The ridge on the surface is not quite so long as the body of the seed, and at its apex there is a gap appearing as a slight notch in the seed. Immature seeds are yellowish-green.

The impurities met with are: true seeds of soft geranium and field pansy; composite fruits: yarrow (No. 27), nutlets of self-heal (No. 40); grass seeds: timothy (No. 47).

The seed of soft geranium (fig. 352) is oblong, 2 × 1 mm., reddish-brown,

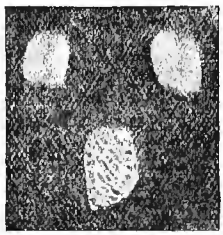


Fig. 352.—Dove's-foot geranium (*Geranium molle*).

Fig. 353.—Pansy (*Viola versicolor arvensis*).

and *smooth* on the surface, without the depression so marked in the cut-leaved species.

The seed of field pansy (fig. 353) is egg-shaped, 2 × 1 mm., glossy and yellow, or brown, with *a special appendage at the narrow end.* This appendage is tiny, shrivelled, and lighter in colour than the body of the seed.

13. *White Clover* (fig. 354).

The seed is pale-yellow, and practically of the same size as alsike—1 to 1¼ mm. The shape is like a heart, for the ridge is thick, *of the same length* as the body of the seed, and gapes away at the base. Immature seeds are greenish. Old seed loses its gloss, darkens, and may become quite red.

The *common impurities* are the same as in alsike and red clover-seeds. Yellow

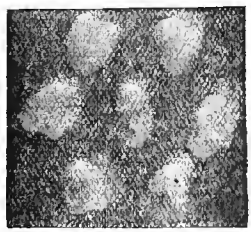


Fig. 354.—White clover (*Trifolium repens*).

suckling clover (No. 14) is sometimes used as an adulterant, and is easily detected by its oval (not heart) shape.

The seeds illustrated on this page are magnified six diameters.

14. *Yellow Suckling Clover* (fig. 355).

The seed is specially glossy and of a warm yellow colour, somewhat like that of a small white clover, but oval rather

Fig. 355.—Suckling clover (*Trifolium minus*).

than heart-shaped; for here the ridge formed by the radicle is scarcely noticeable.

15. *Lucerne* (fig. 356).

In typical examples the shape is kidney-like, and the length varies from 2 to 3 mm. The seed-skin is dull, destitute of gloss, and of a pale-yellow colour, inclining to brown when the seeds are old. The radicle of the embryo is a little more than half the length of the cotyledons, and the cotyledons have a characteristic curve to one side, so that the ridged part of the seed is in one plane and the remainder of the seed in another.

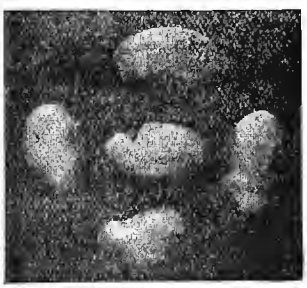


Fig. 356.—Lucerne or alfalfa (*Medicago sativa*).

A common *impurity* is trefoil-seed (No. 16); a common *parasite* is dodder (No. 64); and an adulterant sometimes used is white melilot, otherwise called "Bokhara clover."

This adulterant, though closely resembling lucerne-seed, is easy to detect, because it contains an odoriferous principle—the same which gives the characteristic odour to new-mown hay—namely, *cumarin*. By this characteristic odour an adulterated sample is detected.

16. *Trefoil* (fig. 357).

The seed is greenish-yellow, shaped like a bean, and smaller than lucerne—2½ mm. long and 1 mm. broad. The most useful feature for identifying this cheap seed is the very noticeable *projecting point of the radicle*, which is bent out from the middle of the concavity at right angles to the body of the seed.

In trefoil samples a small flattish black fruit, with raised curved lines on the

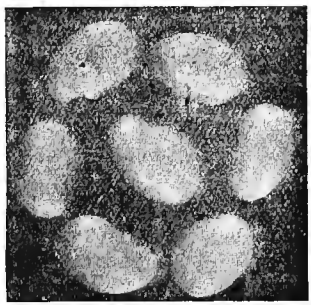


Fig. 357.—Trefoil or yellow clover (*Medicago lupulina*).

surface, is often seen lying in the toothed calyx of its flower. This is the trefoil fruit, as we easily know, for on opening the black seed-case, a kidney-shaped seed is seen with the characteristic projecting point of trefoil.

17. *Bird's-foot Trefoil.*

The seed of the useful trefoil is almost globular, 1¾ mm. long, 1½ mm. broad, and 1 mm. thick. The colour is dark-brown, mottled with white spots. Marsh bird's-foot trefoil—the useless species—is often substituted. Its seeds, however, are only half as long, at most 1 mm., and the colour is greenish.

18. *Kidney Vetch* (fig. 358).

The seed is oval, 2½ mm. long, and easily distinguished by the colour—one end of the oval being green and the other yellow. The yellow end becomes brown with age.

The seeds illustrated on this page are magnified six diameters.

THE TWO-FACED RIB-GRASS SEEDS.

These seeds are either brown or at times quite black. When wetted the whole skin, like that of linseed, swells up into mucilage, and in the mouth this mucilaginous character becomes immediately revealed. There are always two different faces on these seeds — an inner flat or grooved, and an outer convex. Tried by the knife the seed cuts like a piece of horn.

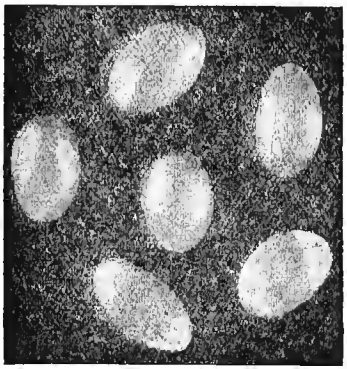


Fig. 358.—Kidney vetch (*Anthyllis vulneraria*).

19. *Rib-grass* (*Plantago lanceolata*) (fig. 359).

The seed is smooth, brown, and of an oval outline, 2½ × 1¼ mm., like a miniature date-stone with a broad instead of a narrow furrow on the inner face. Sometimes the groove is hidden by a fragment from the seed-case, which remains adherent to the inner face. This is one of the commonest impurities in clovers, especially in red clover.

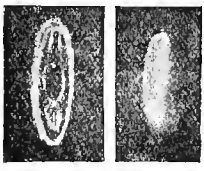


Fig. 359.—Rib-grass (*Plantago lanceolata*).

Fig. 360.—Way-bread (*Plantago major*).

20. *Greater Rib-grass or Way-bread* (fig. 360).

The seed is rough and black, and the inner face is flat without the groove.

CLASS II.—FRUITS.

Fruit is always something more than a seed; there is a closed seed-case in addition. Take a common hazel-nut for example: here, the kernel is the seed, and the hard shell the seed-case. These two parts are always constituents of a fruit. It is easy, then, to identify these fruits: cut the fruit across, and the seed-case is seen enclosing a seed in its cavity.

THE FLAT BEAKED "SEEDS" OF BUTTERCUPS.

One buttercup flower produces many "seeds," but if we cut into one of these so-called seeds we find the two constituents which mark a fruit—namely, the seed-case and the seed within.

21. *Upright Buttercup* (fig. 361).

The "seed" is flat and lop-sided shaped, somewhat like the figure 6. The rounded part of the 6 corresponds to the body of the seed, and the stroke to the apical beak. The seed-case is brown and of leathery texture, about 3½ × 2 mm.

Fig. 361.—Upright crowfoot (*Ranunculus acris*).

Fig. 362.—Creeping crowfoot (*Ranunculus repens*).

22. *Creeping Buttercup* (fig. 362).

This species is larger than No. 21, and its beak is longer as well as more curved. Among the seeds of corn crops a common impurity is the fruit of the *corn buttercup*, readily distinguished from ordinary buttercups by its *spiny surface*. Compare the flat, black, symmetrical (not lop-sided) beaked "seeds" of red-shank, No. 26*a*.

The seeds illustrated on this page are magnified six diameters.

THE THREE-FACED "SEEDS" OF THE DOCK FAMILY.

In this family are included cultivated buck wheats, often called "grain crops," and many pestilent weeds, such as docks and sorrels. The invariable rule in the family is one flower, one fruit, never many as in buttercup. The fruit has a character which renders identification easy; it has three similar faces, or, in other words, the section is triangular. When cut with a knife the seed-case is distinguished, and the seed within the case is seen to be filled with snow-white starchy meal surrounding the embryo plant.

23. *Buckwheat* (fig. 363).

The three-faced fruit is of egg-shaped outline, pointed at both ends, 5 × 3 mm.,

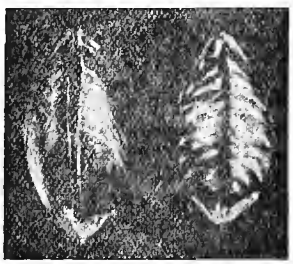


Fig. 363.—Buckwheat
(*Polygonum Fagopyrum*).

and girt at the base with the persistent calyx of the flower which made it. The colour is a glossy dark-brown with a greyish tinge. Old seeds lose their gloss, and split along the three edges.

In the Tartarian species of buckwheat the edges are not sharp and entire, but rounded off and slightly indented.

24. *Curled Dock.*

The three-sided fruit is like a small buckwheat, 2¼ × 1¼ mm., and of a glossy reddish-brown tint.

25. *Sheep's Sorrel* (fig. 364).

The three-sided fruit is like a small dock, *only* 1 *mm. long*, and glossy reddish-brown. This, like rib-grass, is one of the commonest impurities in clover-seeds.

THE FLAT AND BEAKED "SEEDS" OF THE DOCK FAMILY.

In certain members of the Dock family the "seed" is not three-faced, but a flat symmetrical disc with a beak projection from its apex. These

Fig. 364.—Sheep's sorrel
(*Rumex acetosella*).

seeds are the common impurities called persicarias or red-shanks. When cut across they resist the knife like tough horn, and are seen to be destitute of white meal.

26*a*. *Spotted Persicaria or Red-shank* (fig. 365).

The fruit is a round, glossy, black disc, 1½ to 2½ mm. in diameter, with a sharp point projecting from its apex. This disc is two-faced—the one face flat, the other slightly convex, and where

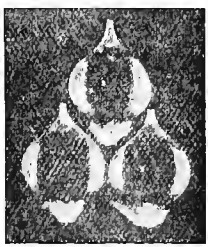


Fig. 365.—Red-shank
(*Polygonum Persicaria*)

the two faces blend they form a sharp edge round the disc. Red-shank is a common impurity in clover-seeds.

26*b*. *Pale-flowered Persicaria* (*Polygonum Lapathifolium*).

The seed is distinguished from that of spotted persicaria by the two faces being concave, and by the thick rounded (not sharp-edged) margin of the disc.

The seed illustrated in fig. 363 *is magnified four-and-a-half diameters; the seeds in figs.* 364 *and* 365 *six diameters.*

"SEEDS" OF COMPOSITES.

These are never true seeds, but always fruits, each composed of a seed completely enclosed in a hard, dry seed-case. The invariable rule is one flower, one fruit. It is specially noteworthy that this fruit is never made inside the flower, but always on the outside from what is technically called an inferior ovary. A composite "seed" is accordingly never found seated in a persistent calyx. The sign of external origin is found at the apex of the seed-case, where special scars or persistent relics of the flower-leaves are usually to be recognised.

The forage plants included among composites are yarrow and chicory, and the common weeds are ox-eye daisy, field chamomile, knapweed, field thistle, dandelion, and nipplewort.

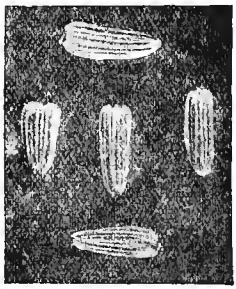


Fig. 366.—Yarrow, or milfoil (*Achillea Millefolium*).

27. *Yarrow* (fig. 366).

The "seed" is flat and blunt at the apex, and tapers off gently to the rounded base. The colour is silvery grey, with narrow white wings like expansions along the two margins. The dimensions are 2 × 1 mm.

28. *Ox-eye Daisy* (fig. 367).

The "seed" is four-sided, and *strongly ribbed*. The apex is blunt, and tapers off gradually to the blunt base. The dimensions are 2 × 1 mm. Corresponding to the white florets of the daisy head there are the "seeds" with a membranous crown, and to the yellow flowers of the centre those other seeds destitute of crown. These "seeds" occur as impurities in clovers.

29. *Field Chamomile* (fig. 368).

The "seed" closely resembles that of ox-eye. It is often bent, and none of the seeds have the membranous crown. These "seeds" also occur as impurities in clovers and cereals.

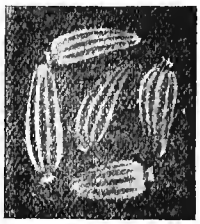


Fig. 367.—Ox-eye daisy (*Chrysanthemum leucanthemum*).

Fig. 368.—Field chamomile (*Anthemis arvensis*).

30. *Knapweed* (fig. 369).

The "seed" is stout, and the broad, blunt apex bears a crown composed of numerous fair hairs, inclining to red. The seed-case is quite smooth on the surface, and shines like white porcelain tinged with violet. At the side of the narrow base there is a well-marked scar, as if a morsel had been bitten out there. The dimensions are: for the seed-case, 3 × 1½ mm.; for the hairs, 1½ mm.

Fig. 369.—Knapweed (*Centaurea nigra*).

Fig. 370. — Field thistle (*Carduus arvensis*).

31. *Field Thistle* (fig. 370).

The "seed" is somewhat three-sided, and of egg-shaped outline, 3 × 1 mm. The glossy seed-case is whitish, and its broad apex bears a knob-like projection, surrounded by a ring-like swelling.

The seeds illustrated on this page are magnified six diameters.

32. *Chicory* (fig. 371).

The fruit is quadrangular, 2½ × 1½ mm., with the broad apical end quite

Fig. 371.—Chicory (*Cichorium intybus*).

blunt, and *crowned with a multitude of minute blunt scales.* The colour is mottled fawn.

33. *Dandelion* (fig. 372).

The leather-like seed-case is 2 mm. long and ½ mm. broad. Its surface is ribbed and spiny towards the apex, which is prolonged as a cylindrical beak, whose length depends upon where the break across occurred.

Fig. 372.—Dandelion (*Taraxacum officinale*).

Fig. 373.—Nipplewort (*Lapsana communis*).

34. *Nipplewort* (fig. 373).

The "seed" is flat and club-shaped, 4 × 1 mm. Under a lens the surface shows very fine longitudinal striations.

CLASS III.—MERICARPS.

The word is the Greek for *part of a fruit.* It signifies a part split off from a fruit, and is constructed of a seed-case enclosing one seed. In runch, for example, the fruit is jointed like a short string of beads, and each joint when it detaches is rightly called a mericarp, for it is a part of a fruit, and it is constructed of a closed case containing one seed. (See Runch, No. 7.) In the mericarps dealt with here the fruit splits longitudinally into two pieces: each piece is a mericarp with two faces, the inner face being formed by splitting.

UMBELLIFEROUS "SEEDS."

The seed here is formed from a fruit which splits not as in runch transversely into many pieces, but lengthways into only two pieces or mericarps. Each mericarp is composed of a seed within a closed seed-case, with an inner surface (at which the split occurred) and an outer surface. A striking peculiarity of the seed-case is the presence of *canals containing coloured oil.* These appear on the outside as coloured lines. Among the plants included here are parsnip, parsley, and carrot.

35. *Parsnip.*

The seed is a *flat disc* about 7 mm. long and 5 mm. broad, with very low ridges on its outer face. The colour is like straw, with dark, well-marked oil-canals between the ridges.

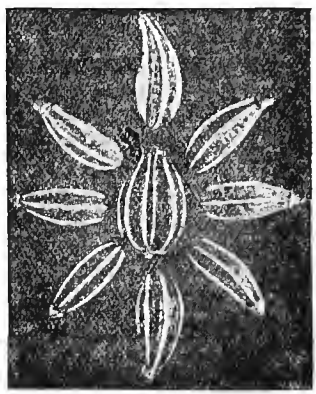


Fig. 374.—Parsley (*Petroselinum sativum*).

36. *Parsley* (fig. 374).

The greenish-grey "seed" when lying on its flat inner split face shows an egg-shaped outline about 2½ × ¾ mm., surmounted by a conical swelling at the

The seed illustrated in fig. 374 is magnified four-and-a-half diameters; the seeds in figs. 372 and 373 six diameters; the seed in 371 ten diameters.

narrow end. Three well-marked light-coloured ribs are seen on the outer face standing out clearly against the dark background between the ribs.

37. *Carrot.*

The grey seed has rows of *prickly ridges* on its surface, and if fresh, gives off a faint odour of aniseed. The length is about 2½ mm.

"SEEDS" OF THE CLEAVERS FAMILY.

The "seed" here is again a mericarp formed from a fruit which splits longitudinally into two mericarps. Each mericarp is constructed of a seed within a closed seed-case, which shows an inner surface (formed by splitting) and an outer surface. This seed-case, however, is destitute of ridges and oil-canals. The true seed is of horny texture, and when cut across, shows a section of the embryo embedded in the horny material. The "seeds" of two members of this family—namely, cleavers and sherardia—are ubiquitous impurities in seeds, the cleavers in corn and the sherardia in clovers.

38. *Sherardia* (fig. 375).

The seed-case, 3 × 1½ mm., is flat on the inner face, formed by splitting, but convex on the outer surface. The colour

Fig. 375.—Field madder (*Sherardia arvensis*).

is buff, and marked all over with white dots, which under the lens turn out to be little stiff hairs. The fruit, which splits into the two mericarps, was originally outside the flower, and the calyx leaves of this flower, five in number, persist at the apex as a crown of teeth. The five leaves of this calyx are shared between the two parts into which the fruit splits, thus giving 2½ leaves per part. Hence each "seed" of sherardia is readily recognised, even with the naked eye, by this *crown of 2½ leaves which looks like three sharp teeth.* Sherardia "seed" frequently occurs as an impurity in clover-seeds, usually unsplit and crowned with the five teeth.

39. *Cleavers.*

The "seed" is purplish, and shaped like a very much curved kidney, the concavity representing the inner surface formed by splitting. The length varies up to 3 mm. The convex surface of the seed-case is, in typical examples, covered over *with hooked bristles.* The seed of cleavers is a common impurity in corn.

CLASS IV.—NUTLETS.

These occur in two distinct families of plants, represented by forget-me-not or scorpion-grass (*Myosotis*) and self-heal (*Prunella*). Each flower forms a cluster of four nutlets pressed close together in a ring thus. The nutlet accordingly shows three faces, two flat and an outer convex. The name is appropriate, for each nutlet is a nut in miniature, with a *thick hard shell*, enclosing one seed.

40. *Self-heal* (fig. 376).

The nutlet is egg-shaped, 2 × 1 mm., and of a glossy dark-brown colour. Its

Fig. 376.—Self-heal (*Prunella vulgaris*).

narrow base bears a characteristic *white triangular flap.*

The "seeds" are remarkable for the following peculiarity which distinguishes

The seeds illustrated on this page are magnified six diameters.

them from all others. When in water for a minute, *four clear ridges of mucilage appear* and project, one along the middle line of the outer face, and three others, one along each of the three edges. This peculiar formation depends upon the presence of special cells located along the lines indicated and capable of swelling strongly in water.

41. *Forget-me-not or Scorpion-grass* [*Myosotis versicolor*] (fig. 377).

The nutlets here are black and egg-shaped, about half the size of the nutlets

Fig. 377.—Scorpion-grass (*Myosotis versicolor*).

of self-heal. The shell of this nutlet has no mucilage.

CLASS V.—MULTIPLE FRUITS.

A multiple fruit is formed from a whole cluster of flowers, each of which becomes fruit, but the various fruits of the cluster are grown together to form one mass. The rule is, many flowers, one fruit. A large example is the pine-apple: each rhomboidal area seen on its surface corresponds to one flower of the cluster. In the same way each chamber of a mangel "seed" represents a mangel flower.

42. *Mangel.*

The "seed" is a multiple fruit formed of three or more very hard and thick-walled fruits, grown together, and each one of these may contain a true seed. When the "seed" is cut across it is seen to be a chambered body, and the snow-white meal contained in the true seed now becomes very noticeable. Here we have a case where the germination of the "seeds" may be 300 per cent. This is because each so-called seed is a multiple fruit containing three seeds, capable of producing three seedling plants.

CLASS VI.—GRASS "SEEDS."

The "seed" of a grass never is a true seed. It may be the grain fruit, as in shelled timothy; the detached part of a spikelet (fig. 384), as in rye-grass; the whole spikelet, wanting the chaff (glumes), as in the "double seed" of tall oat; or even the whole spikelet, as in meadow foxtail. In most cases, however, the "seed" is a detached part of the spikelet; and such a part is distinguished by the presence of a *stalk*, which lies next the *upper* valve of the husk. The *lower* valve of the husk is on the other face of the "seed," away from the stalk. For purposes of distinction, it is important to pay special attention to this lower valve of the husk. Sometimes the "seed" can lie on its back, and then, of course, the lower valve of the husk is rounded off thus ⌣. In certain other cases, where the seed lies on its side, and cannot lie on its back, this lower valve is V-shaped. The seeds that lie on the side are: cocksfoot, all the *poas*, and purple molinia.

In still other cases an awn springs sometimes from the back and sometimes from the base of this lower valve, as in golden oat, aira.

Grass "seeds" are accordingly—

a Complete spikelets.
b The whole of the spikelet except the chaff (glumes).
c Detached portions of the spikelet with rounded back.
d The same with V-shaped back (keeled).
e The same with awn from back or base.

In exceptional cases, such as shelled timothy and shelled cocksfoot, the "seed" is the grain fruit.

a. THE "SEED" IS THE WHOLE SPIKELET.

This is the case in three grasses: meadow foxtail, slender foxtail, and Yorkshire fog, or unshelled holcus as it is sometimes called.

The seed illustrated in fig. 377 *is magnified six diameters.*

43. *Meadow Foxtail* (fig. 378).

Each "seed" of foxtail is a whole spikelet containing one grain. The length is 5 mm., and the breadth at the widest part—midway between apex and base—is 2½ mm. The spikelet is quite flat, and is covered all over with velvety hairs. Along each margin there is a conspicuous fringe of these hairs. At the apex there projects from the inside of the spikelet a long but fine awn. The colour of the "seed" is greyish-yellow, if ripe; if unripe, quite pale.

Fig. 378.—Meadow foxtail grass (*Alopecurus pratensis*).

The adulterants used are spikelets of slender foxtail (No. 44) and Yorkshire fog (No. 45).

The impurities are portions of grass spikelets, usually tufted hair-grass (No. 63) and poas (No. 59), entangled in the hair fringes of the foxtail "seed."

44. *Slender Foxtail* (fig. 379).

This "seed," as compared with meadow foxtail, is longer (over 6 mm.), duller in colour, bald, and *destitute of the marginal fringes of hair.*

45*a*. *Yorkshire Fog* (fig. 380).

This spikelet, sometimes called "unshelled holcus" (on the left of fig. 380), is only 4 mm. long, and wants the projecting awn. When the spikelet is opened up it is found to contain two flowers (instead of one, as in foxtail), with husks which gleam like polished silver. The upper of the two flowers is remarkable and very characteristic, for just behind the point of its husk it has a short awn, which at maturity is bent inwards *like a fish-hook.* The lower

Fig. 379.—Black grass (*Alopecurus agrestis*).

flower with its husk is called "shelled holcus" when detached from the rest of the spikelet.

45*b*. *Yorkshire Fog* (*Holcus mollis*).

The creeping species of Yorkshire fog (*Holcus mollis*) is sometimes used as an adulterant for meadow foxtail. The spikelet of this species is like that of Yorkshire fog, but is immediately dis-

Fig. 380.—Yorkshire fog (*Holcus lanatus*).

tinguished by the presence of a long awn projecting from the apex. The awn here, instead of being bent in and hidden by the chaff (glumes), projects far beyond the chaff (glumes).

The seeds illustrated on this page are magnified six diameters.

45c. *Shelled Holcus.*

This "seed" is not the spikelet of Yorkshire fog, but the detached part of the spikelet (on the right of fig. 380) enclosing the grain in a husk which is much longer than the grain within. It is very like timothy seed, but *longer*, over 2 mm., and has a *stalk* on the flat inner face. To distinguish shelled holcus from timothy requires careful examination with a good pocket lens.

b. THE "SEED" IS THE WHOLE SPIKELET EXCEPT THE CHAFF (GLUMES).

This is the case with the two cultivated grasses, tall oat-grass or French rye-grass and timothy.

46. *Tall Oat-grass or French Rye-grass* (fig. 381).

The "seed" is 8 or 9 mm. long, and is called a "double seed," for it is composed of two flowers. These flowers are differently constructed. The lower flower is barren, and from the back of its husk there springs a long awn (12 mm.), coarse, dark, and twisted at the base, but fine, light coloured, and bent at the apex. The upper flower is fertile, containing the grain, and its awn is fine, short, and quite straight. The distinctive feature is the presence of *two awns*—one long and conspicuous, the other quite short and easily overlooked. An adulterant sometimes used is *rye brome* (No. 57). This "seed" is single, a mere part detached from a spikelet, and not a "double seed" with two awns.

47. *Timothy* (fig. 382).

The "seed" is the whole contents of the spikelet minus the chaff; but unlike tall oat, there is in this case only one flower to make the "seed." Timothy "seed" is composed of a grain enclosed in a thin, transparent, silvery husk. The dimensions are 1½ mm. to 2 mm. long and ¾ mm. broad. This husk readily allows the grain to escape, so that at times timothy seed is the mere grain, bare of husk, called *shelled timothy*. This grain is golden and easily distinguished; for, unlike the grain of most other grasses, it is almost globular, without the flat face and groove familiar to us in the large wheat grain.

The common impurities are: (1) True seeds of rib-grass (No. 19); (2)

Fig. 381.—Tall oat-grass (*Avena elatior*).

fruits of sheep's sorrel (No. 25); (3) nutlets of self-heal (No. 40); (4) *shelled holcus* (No. 45c); (5) detached por-

Fig. 382.—Catstail or timothy (*Phleum pratense*).

tions of grass spikelets with awn from the base of the lower valve of the husk; tufted hair-grass (No. 63).

Seed of the parasite dodder (No. 64) may occur in timothy seed sieved off from clover. Ergot (No. 66) frequently occurs.

The seed illustrated in fig. 381 *is magnified six diameters; the seed in fig.* 382 *ten diameters.*

c. THE "SEED" IS A PORTION OF THE SPIKELET WITH STALK ON UPPER FACE; BACK ROUNDED.

The "seed" in this group of grasses is composed of a grain enclosed within a two-valved husk. The lower valve of

Fig. 383.—Italian rye-grass (*Lolium italicum*).

Fig. 384.—Perennial rye-grass (*Lolium perenne*).

the husk is rounded so that the "seed" can lie on its back. The valuable seeds are: rye-grasses, fescues, and crested dogstail; the worthless weed seeds: fescue hair-grass and bromes. Shelled holcus, which belongs here, is described under No. 45*c*.

48. *Italian Rye-grass* (fig. 383).

The "seed" closely resembles that of perennial rye-grass, but the presence of an apical beard or awn readily distinguishes.

The common impurities are: (1) True seeds, rib-grass (No. 19); (2) fruits, composed of a seed-case enclosing one seed, buttercups (Nos. 21 and 22), docks, and sorrels (Nos. 24 and 25); (3) composite fruits, ox-eye daisy (No. 28), and nipplewort (No. 34); (4) detached portions of grass spikelets, the fescue hairgrass (*Festuca sciuroides* or *Festuca myurus*) (No. 55); (5) complete grass spikelets, Yorkshire fog (unshelled holcus) (No. 45*a*).

49. *Perennial Rye-grass* (fig. 384).

The "seed" is a detached portion of the spikelet, consisting of a grain enclosed in a two-valved husk. The length varies from 6 mm. to 7 mm., and the longer-seeded sorts, with the husk considerably longer than the enclosed grain, usually come from *annual* rye-grasses. There is no beard or awn on the lower valve of the husk as in Italian. The stalk is *flat, broader at the apex than at the base*, and has no apical flange.

The common impurities are: (1) True seeds, rib-grass (No. 19); (2) fruits, each composed of a case enclosing a seed, buttercups (Nos. 21 and 22); (3) detached portions of grass spikelets with rounded back, goose or brome grass (No. 56); (4) grass spikelets complete, Yorkshire fog (unshelled holcus) (No. 45*a*).

50. *Meadow Fescue* (fig. 385).

The "seed" is a detached portion of the spikelet. The husk is 6 mm. long, and ends in a broad blunt point, very frequently broken. The stalk is a

Fig. 385.—Meadow fescue-grass (*Festuca pratensis*).

Fig. 386.—Tall fescue-grass (*Festuca elatior*).

narrow cylinder, 1¼ mm. long, with a flange at its apex.

The common impurities are: soft brome (No. 56) and rye brome (No. 57). An adulterant "seed" is perennial rye-grass (No. 49).

51. *Rhenish Tall Fescue* (fig. 386).

The "seed" closely resembles that of meadow fescue. It differs, however, in the following points: (1) *The colour is*

The seeds illustrated on this page are magnified six diameters.

darker; (2) the length is slightly greater; and (3) the whole "seed" is narrower, especially at the point, which is never broken. Colour alone suffices for distinction.

A common impurity is cocksfoot (No. 58), and a common substitute New Zealand tall fescue (No. 52).

52. *New Zealand Tall Fescue.*

The "seed" differs from that of Rhenish tall fescue in the following points: (1) *The colour is light,* as in cocksfoot; (2) the length is over 7 mm.; and (3) the point is hard and sharp, ending in a very short awn. Colour is the best distinction.

53*a*. *Sheep's Fescue* (fig. 387).

The "seed" is narrow, 4 *or* 5 *mm. long,* and only sometimes tipped with a very short awn (1 mm.) The husk is firm, and of a straw-yellow colour. The impurities are wavy hair-grass (No. 62) and purple molinia (No. 60), which lies on the side. Hard fescue is sometimes substituted.

Fig. 387.—Fine-leaved fescue (*Festuca ovina tenuifolia*).

Fig. 388.—Hard fescue-grass (*Festuca duriuscula*).

53*b*. *Hard Fescue* (fig. 388).

This is a longer "seed," its body 6 or 7 mm., and *its awn* 5 *mm.*

54. *Crested Dogstail* (fig. 389).

The "seed" is 4 mm. long, or including the awn, 4½ mm., and 1 mm. broad. The colour is bright yellow at the narrow end, shading to reddish-brown at the broad end. The bristly point of the lower valve of the husk is bent slightly to the side, and ends in a rigid sharp point. The stalk is a very short cylinder, terminating in a disc-like flange.

Fig. 389.—Crested dogstail-grass (*Cynosurus cristatus*).

A common impurity is Yorkshire fog shelled (shelled holcus) (No. 45*c*).

55. *Fescue Hair-grass or Hair-grass* [*Festuca myurus*] (fig. 390).

The "seed" is excessively fine and dark, like a grey or brown hair, 15 mm. long. The base of this hair is slightly swollen for a length of 5 mm. The swollen base is the body of the seed, and the apical portion the awn. This occurs as an impurity in rye-grasses.

56. *Soft Brome* (fig. 391).

The "seed" is awned broad and flat, with each of its two edges forming an angle instead of a curve at the broadest part near the apex. The stalk is slightly conical, and broadest at the apex. The upper valve of the husk next the stalk is decidedly shorter than the other. The dimensions are 9 mm. long, and including the awn about 17 mm.

57. *Rye Brome* (fig. 392).

This is a narrow cylindrical seed about 7 mm. long, and including the short awn some mm. more. The cylindrical appearance and narrowness, as compared with soft brome, is due to the strong inrolling of the lower valve of the husk towards the upper face of the "seed."

The seeds illustrated in figs. 387 *and* 389 *are magnified ten diameters; the seed in fig.* 388 *six diameters.*

d. THE "SEED" IS A PORTION OF THE SPIKELET: BACK V-SHAPED.

This group of grass "seeds" includes cocksfoot and *poas* (meadow grasses), as well as the adulterant purple molinia or flying bent.

58. *Cocksfoot* (fig. 393).

The "seed" is a detached portion of the spikelet, consisting of a husk enclosing a grain. Sometimes, in *immature* samples, the detachment is incomplete; then we have "double, often treble, seeds." These "double seeds," unlike those of tall oat, are not the whole contents of the spikelet, but only a detached portion. The length is 5 mm., or including the short awn 6 or 7 mm. The colour is very light, inclining to golden white. The point of the husk, like that of crested dogstail, has a slight *bend to the side.*

Fig. 390.—Squirrel-tail fescue-grass (*Festuca sciuroides*).

Fig. 391.—Soft brome-grass (*Bromus mollis*).

Common impurities are: dock fruits (No. 24), grass spikelets of Yorkshire fog (No. 45*a*), and detached portions of grass spikelets rounded on the back—soft brome (No. 56).

Fig. 392.—Rye seeded brome-grass (*Bromus secalinus*).

Fig. 393.—Cocksfoot-grass (*Dactylis glomerata*).

Adulterants sometimes used are: detached portions of grass spikelets with rounded back, such as perennial rye-grass (No. 49) and hard fescue (No. 53*a*).

Fig. 394.—Smooth-stalked meadow grass (*Poa pratensis*).

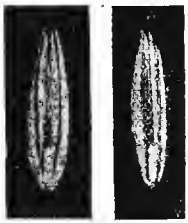


Fig. 395.—Rough-stalked meadow grass (*Poa trivialis*).

59. *Poas or Meadow Grasses* (figs. 394 and 395).

The "seed" is a detached portion of the spikelet, consisting of a grain enclosed

The seeds illustrated in figs. 390, 391, 392, *and* 393 *are magnified six diameters; the seeds in figs.* 394 *and* 395 *ten diameters.*

in a two-valved husk. It cannot lie on its back, for the lower valve of the husk is V-shaped. This husk is never transparent, and never has an awn. The "seeds" are always small, ranging in length from 2½ to 3½ mm. For distinguishing the various species microscopic examination is necessary, and so full consideration of the distinctive characters is unnecessary here.

By the aid of a good pocket lens, however, the "seed" of the *rough-stalked meadow grass* may be recognised if the *end "seed"* of the spikelet is selected for examination. The stalk of this seed is very slender, and has a *globular rudiment* at its end, whereas the corresponding seed of *smooth-stalked meadow grass* has a stalk twice as thick, and the *rudiment is long and pointed.* An adulterant of *poas* sometimes met with is purple molinia, a much larger seed (No. 60). Aira seeds (Nos. 62 and 63) are also used, but the presence of the basal awns at once detects such substitutes.

60. *Purple Molinia.*

The "seed" is a detached portion of the spikelet. The points of distinction from dogstail seed, for which this is sometimes substituted, are: (1) The molinia seed lies on its side; (2) it is often longer by about 1 mm.; (3) the colour is darker brown, with a purplish tip; (4) the stalk is comparatively long, from 1½ to 2 mm., and ends not in a flange, but *in a cleft knob;* (5) the husk often gapes at the point, like the open beak of a bird.

This gape is very characteristic, and is due to the excessive narrowness of the lower valve of the husk, which cannot surround and tuck in the point of the upper valve.

e. THE "SEED" IS A PORTION OF THE SPIKELET WITH THE BACK OR BASE AWNED.

The valuable grass here is golden oat, with the awn from the back; the worthless weeds, the *airas* — namely, wavy hair-grass and tufted hair-grass, with the awn from the base.

61. *Golden Oat* (fig. 396).

The "seed" is a detached portion of the spikelet, consisting of grain and husk. The length is about 4½ mm. The husk is very thin, and coloured like

Fig. 396.—Golden oat-grass (*Avena flavescens*).

gold. From its back, *midway between apex and base*, there springs forth a bent awn. The stalk is very characteristic, and looks like a little white feather, for it is flanged with two rows of white hairs.

A common adulterant is wavy hair-grass "seed" (No. 62).

62. *Wavy Hair-grass* (fig. 397).

The "seed" is 5 mm. long, and most readily distinguished from that of golden oat, for which it is a common substitute,

Fig. 397.—Wavy mountain hair-grass (*Aira flexuosa*).

Fig. 398.—Tufted hair-grass (*Aira cæspitosa*).

(1) by the darker and browner colour; (2) by the straight awn springing from the *base*, not the back of the husk; and (3) by a conspicuous basal tuft of white hairs.

The seeds illustrated in figs. 396 *and* 397 *are magnified six diameters; the seed in fig.* 398 *ten diameters.*

63. *Tufted Hair-grass* (fig. 398).

The "seed" is a detached portion of the spikelet constructed of a thin, silvery, transparent husk containing a grain. The "seed" is only 2 mm. long, and very narrow. Round the base there is a conspicuous tuft of hairs, and from the base also there springs a fine awn which has the same length as the body of the "seed." This hair-grass "seed" occurs as an impurity in foxtail. When the foxtail is ripe the hair-grass is only in flower, with no grain as yet developed, and so impotent to reproduce the plant.

CLASS VII.—SEEDS OF PARASITES.

The parasitic flowering-plants, whose seeds are often found in clovers and in timothy seed sifted off from clovers, are dodder and clover-rape.

64. *Clover-dodder* (fig. 399).

The seeds look like little *pieces of grey earth*, but, unlike earth, they do not crumble when pressed beneath a knife blade. Under the microscope they are seen to be tiny globules more or less angular, ¾ mm. in diameter. To see the seed contents, which are peculiar, the seeds are boiled in potash, and then squeezed between two glass plates. The cylindrical, yellow embryo, rolled in three

Fig. 399.—Clover-dodder (*Cuscuta Trifolii*).

turns round the transparent endosperm, now becomes apparent, and marks the dodder seed.

65. *Clover-rape* (*Orobanche minor*).

The seeds are very small — about $\frac{1}{5}$ mm. long, like particles of *fine dark-brown or black sawdust*. Under the microscope each seed appears as an iridescent club with a netted surface.

66. *Ergot in Timothy "Seed."*

Ergot is not a seed, but the body of a fungus in a resting state. This ergot as it appears in a timothy is a black rod about 1 mm. broad, and from 2 to 4 mm. long. The rod when cut across is white inside. Such ergots when sown produce spores which spread the fungus to the timothy grass.

The seed represented in fig. 399 *is magnified six diameters.*

CORN CROPS.

CORN-GROWING.

The present position of corn-growing in the United Kingdom is highly interesting and instructive. Without doubt it is here and elsewhere the oldest of arts, and it is pretty certain to be the most enduring; for, notwithstanding the plenteous supplies of artificial foods promised us by the chemist, bread is likely to remain the staff of human sustenance.

The annual consumption of bread-corn in this country averages about 440 lb. per inhabitant, and far exceeds that of all other foods put together, not excluding potatoes, which largely take the place of bread with meat. Its consumption increases not only with the increase of population, but also with every improvement in the social condition of the people as a result of higher wages, and a raising of the standard of living amongst the working classes.

But whilst we are much the largest consumers of corn per head of population, and ourselves barely raise a quarter of the amount needed for home consumption, we devote a smaller proportion of our cultivation to its production than

any other corn-growing country. Under the unfair competition encouraged by our one-sided free-trade policy, most people in this country have come to regard corn as a crop not worth growing so long as it can be imported at a low price. So accustomed have we become to this view of the matter, that we unthinkingly take it for granted that it is cheaper to bring corn from Canada, Australasia, India, Russia, the Argentine, or any part of the world, than it is to grow it for ourselves. Yet, when we are being told that corn-growing here does not pay, and we are year by year reducing the area of our corn-fields, it is not a little interesting to note that other European countries, which already have a far larger proportion of their cultivated lands under corn than we have, are steadily increasing this proportion.

It is true that we have not the fine climate for wheat-cultivation that some other countries have, yet a large part of these islands is well adapted for wheat; while for oats and barley we need fear no competitors, and we have the immense advantage of the home market for all of them. There is, indeed, less difference than might be imagined in the value to the farmer of the different kinds of grain crops, although the market quotations would seem to indicate otherwise. Thus, according to the Board of Agriculture Returns, the grain prices in this country for 1906 were: Wheat, 31s. 6d.; barley, 26s.; oats, 19s. per qr.; and the average yields were 33 bushels, 40 bushels, and 52 bushels per acre respectively. From these figures we find that the average value of the grain crop last year, exclusive of the straw, was £6, 7s. 9d. per acre; but if we add the value of the straw, the average total value of the grain crop is found to have been £9, 2s. 1d., as seen in the following table:—

TABLE OF GRAIN CROP VALUES.

Crop.	Grain.						Straw.		Total value of crop per acre.
	Bushels per acre.	lb. per bushel.	lb. per acre.	Price per qr.	Price per lb.	Value per acre.	Value per qr.	Value per acre.	
				s. d.	Pence.	£ s. d.	s. d.	s. d.	£ s. d.
Wheat.	33	60	1980	31 6	0.79	6 9 11	14 0	57 9	9 7 11
Barley.	40	50	2000	26 0	0.78	6 10 0	8 0	40 0	8 10 0
Oats .	52	39	2028	19 0	0.73	6 3 6	10 0	65 0	9 8 6
Average	41⅔	49⅔	2002	25 6	0.76	6 7 9	10 8	54 3	9 2 1

But no good farmer is content to grow less than 40 bushels of wheat, 50 bushels of barley, or 60 bushels of oats per acre; nor to have the weights much less than 64 lb., 56 lb., and 42 lb. respectively; and 40 bushels of wheat per acre is often exceeded. But even 40 bushels, instead of 33, at the above prices, makes the wheat crop worth £11, 7s. 6d. per acre, which shows that corn-growing in this country is not played out yet, and that few, if any, of the other staple crops will pay better *for the same amount of labour*.

British Resources for Corn Production.—What will be the economic relation of British to Colonial and foreign wheat-growing in the next few years is a matter of doubt. But in the event of our being involved in a great European war, or any such calamity, there is much satisfaction in knowing that this country has an immense reserve for corn-growing in its thirty-three million acres of cultivated grass lands which could be put under corn if necessary, and one-fourth of which would suffice to grow all the grain we now need to import. That this is no exaggeration it would be easy to prove. It must here suffice to mention that we have this latent or potential power of

corn-production in case of need, and that the production could be kept up year after year, as long as required, without the least disorganisation of the agriculture of the country.

VARIETIES OF CORN.

Wheat, like all true cereals and grasses, belongs to the natural order *Gramineæ*. In treating of the plants cultivated on a farm, systematic writers on agriculture describe their characters in minute botanical phraseology. This is right when different species of plants have to be distinguished from each other. When mere varieties and sub-varieties are numerous, they should be described in a more easily understood if less scientific method, so that others besides botanists may easily distinguish them.

Wheat.

Professor Low enumerated 11 different subdivisions of wheat[1] which were cultivated; while Mr Lawson described 83 varieties,[2] and Colonel le Couteur mentioned having in his possession, in 1836, no fewer than 150 varieties.[3]

Simple Classification.—In view of this large number of different varieties of wheat, it is much to be desired that a method should be established for easily recognising the different kinds of corn by the external characters of the ear and grain. Colonel le Couteur gave a classification of *wheat*, in which he divided all the varieties of wheat into two classes—namely, *beardless* and *bearded*. In so far he imitated the modern botanist, who divides the cultivated varieties of wheat into the two divisions of *barbatum* and *imberbe*, signifying the above conditions. But, unfortunately for the stability of this classification, that distinction is not immutable, for some bearded wheats lose their beards on cultivation, and some beardless ones are apt to become bearded when cultivated on poor soils and exposed situations.

Colonel le Couteur subdivided beardless wheat into white, red, yellow, and liver-coloured, smooth-chaffed, and velvet-chaffed; and the bearded he divided under the same colours. Some varieties of wheat are, no doubt, decidedly downy on the chaff; but others, again, are so very little so, that it is difficult to distinguish them from some of the roughest varieties of smooth-chaffed; and it is known that the same wheat will be differently affected in this respect by the soil upon which it grows. A sharp soil renders the chaff and straw smoother and harder than a deaf one, and the deaf soil has a tendency to produce soft and downy chaff and straw. Downiness is thus not a more permanent character than the beard for establishing the denominations of the great divisions of wheat.

Conjoining the characters of the grain and ear of wheat seems unnecessary, inasmuch as the character of either separately cannot positively indicate the state of the other, and both characters are not required to indicate the superior properties of any variety of wheat for making bread. A miller at once distinguishes the *grain* which will afford the best bread; and neither he nor any farmer could indicate such a property from the *ear* of any wheat.

Colour of Wheat.—Colonel le Couteur assumed that a liver-coloured wheat was a distinctive colour. We never remember to have seen a wheat of a liver-brown colour. All the colours of wheat, we think, may be classed under two primary colours, *yellow* and *red* — for even the whitest has a tinge of yellow, and every dark colour is tinged with red; and as *white* and *red* are the terms by which the colours of wheat have been longest known, these should be retained. The sub-tints of yellow and red might be easily designated.

Classification by the Ear. — Were we to classify both the plant and grains of wheat by *natural marks*, we would make two classifications, one by the ear and the other by the grain, so that each might be known by its own characteristics. In this way confusion would be avoided in describing the ear and the grain. The farmer who grows the wheat plant, and sells it in the grain, should be acquainted with both; but the miller who purchases the grain need know nothing of the ear.

[1] Low's *Ele. Prac. Agric.*, 229.
[2] Lawson's *Agric. Man.*, 29.
[3] Le Couteur *On Wheat*, ii., Dedi.; and 77.

The ears of three classes of wheat are represented in fig. 400, which shows the ears half the natural size. The first, *a*, is a *close* or *compact* eared wheat, which is occasioned by the spikelets being set near each other on the rachis; and this

Fig. 400.—*Classification of wheat by the ear.*

construction makes *the chaff short and broad.* The second class of ears is *b*, the spikelets being of *medium* length and breadth, and placed just as close upon the rachis as to screen it from view; this ear is not so broad, but longer than *a*; the *chaff* is of *medium length and breadth.* The spikelets of *c* are set *open*, or as far asunder as to permit the rachis to be easily seen between them; this ear being about the same length as *b*, but much narrower, *the chaff long and narrow.* There is no chance of confounding these three structures of the ears of wheat.

These three classes of varieties constitute the *Triticum sativum imberbe* of botanists,—that is, all the beardless cultivated wheats. Formerly they were divided by botanists into *Triticum hybernum* or winter wheat, and *Triticum æstivum* or summer wheat; but experience has proved that the summer wheat may be sown in winter, and the winter wheat sown in spring, and both come to perfection. Paxton says that Triticum is derived from "*tritum*, rubbed — in allusion to its being originally rubbed down to make it eatable."[1]

In *d*, fig. 400, is represented a bearded wheat, which shows the appearance the beard gives to the ear. The bearded wheats are generally distinguished by the *long shape* of the *chaff* and the open position of the spikelets, and therefore fall under the third class *c*. But cultivation has not only the effect of decreasing the strength of the beard, but of setting the spikelets closer together, as in the white Tuscany wheat. Bearded wheat constitutes the second division of cultivated wheat of the botanists, under the title of *Triticum sativum barbatum.* The term bearded has been used synonymously with spring wheat, but erroneously, as beardless wheat is as fit for sowing in spring as bearded, and the bearded for sowing in winter.

Classifying by the Grains.—Classified by the grain, wheat may again be grouped under three heads. The first class is shown in fig. 401, where the grains are *small*, *short*, *round*, and *plump*, with the median line distinctly marked and well filled up. Fine *white* wheat belongs to this class, and is enclosed in *short*, *round*, *thin*, and generally *white chaff*, which, when ripe, becomes so expanded as to endanger the grain falling out. Very few *red* wheats be-

Fig. 401.—*Short, round, plump form, and small size of wheat.*

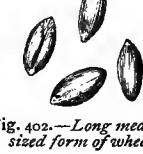


Fig. 402.—*Long medium-sized form of wheat.*

long to this class. In reference to the ear, this class is found in *short-chaffed* and broad spikelets, which are generally compact, as *a*, fig. 400.

The second class is in fig. 402, where the grains are *long and of medium size*, longer and larger than the grains of fig.

[1] Paxton's *Bot. Dic. Tritic.*

401. The *chaff* is also *medium sized.* In reference to the ear, it is of the *medium* standard, in respect to breadth and closeness of spikelets, as *b*, fig. 400, though *medium-sized grain* is *not* confined to this sort of ear, and is found in the *compact* ear as well as in the *open* ear. Most *red* wheat belongs to this class of grain, though many of the *white medium-sized* also belong to it. This grain is the Caucasian red wheat, whose ear is bearded, and belongs to the open-spiked class *c*, fig. 400.

The median line is strongly marked, and the ends are sharp.

In fig. 403 is the third form of grain, which is *large and long.* Its *chaff* is *long*, and in reference to the ear, the spikelets are generally open. The median line is not distinctly marked. The ends of the grain are pointed but not sharp, and the skin is rather coarse. The germ and radicle are boldly marked.

Fig. 403.—*Large size and long form of wheat.*

These three sorts of wheat are of the natural size, and indicate the forms of the principal varieties found in our markets.

Relation of Ear and Grain.—It will be seen from what has been stated, that no inevitable relation exists between the *ear* and *grain;* that the compact ear does not always produce round grain nor white wheat; that in the medium ear is not always found medium-sized grain; and that the open ear does not always produce large long grain.

Still, there exist coincidents which connect the *chaff* with the *grain.* For example, *length* of *chaff* indicates *length* of *grain*, upon whatever sort of ear it may be found; and, generally, the *colour* of the chaff determines *that* of the grain.

On desiring, therefore, to determine the sort of *grain* any number of *ears* of different kinds of wheat contain, the *form* and *colour* of the *chaff* determine the point, and not whether the ear carries compact, medium, or open, bearded or beardless, woolly or smooth spikelets.

Vilmorin's Classification.—M. Henry Vilmorin, in his beautiful work[1] on wheat, adopts the following arrangement:—

Triticum sativum	Soft wheat.
T. turgidum	Plump "
T. durum	Hard "
T. polonicum	Polish "
T. Spelta	Spelt.
T. amyleum	Starchy wheat.
T. monococcum	One-grained "

The most important of these, *T. sativum*, he subdivides according as the variety is awned or unawned, the ear white or red, smooth or downy, and the grain itself white or red. Familiar forms of *T. sativum* are Chidham, Hunter, Trump, Talavera, Hickling, Hallett, Dantzic, Shireff, Browick.

Judging Wheat.—But the classification is unimportant to the farmer, compared to the mode of *judging* wheat, to ascertain the external characters which best indicate the purposes for which the corn may be best employed, in the particular condition of the sample. The purposes are, for seed and for making into flour—whether the flour is to be employed in bread, in confections, or starch.

In its *best* condition, all wheat, whether red or white, small or large, long or round, should appear plump within its skin. The skin should be fine and smooth. The colour should be bright and uniform. The grains should be of the same size and form, and perfect. With all these properties wheat is fitted for every purpose.

Wheat for Flour.—When wheat is quite opaque, it is in the best state for yielding the finest flour. Such flour, from white wheat, confectioners use for pastry, and it contains the largest amount of starch, but it is too dear for the starch-maker. When wheat is translucent, hard, and flinty, it is suited to the baker, as affording flour that rises freely with yeast, having much gluten in it. For bread of finest quality a mixture of the two conditions of flour is best suited.

Some sorts of wheat naturally possess *both* these properties, and are great favourites with millers. Generally speaking, the purest-coloured white wheat indicates most opacity, and yields the finest flour; and red wheat is most flinty, and yields the strongest flour: translucent red

[1] *Les meilleurs blés.*

wheat will yield stronger flour than translucent white wheat, and yet red wheat rarely realises so high a price in the market as white—partly because it contains more bran, makes darker-coloured bread, and yields less starch.

Wheat varying with Soil.—Mr Powles says, in his translation of Kick's treatise: "Wheat varies very much according to the soil and country in which it is grown. Among the best kinds of wheat are the Hungarian and the Banater, though they frequently show a flinty appearance in cross-section. This is not the case with wheats grown in more northern countries. Their grain, which shows in cross-section a uniform white colour, gives better flour, and is called soft or white wheat, whereas that which shows a mottled or flinty cross-section takes the name of hard wheat, and gives less and inferior flour. A fine, clear, glistening exterior and oval form, are a sign of good quality with old wheat, which has been kept for many years in the granary; the recovery of its original colour and lustre after washing and slow drying indicates good quality."[1]

Weight of Wheat.—The weight of wheat varies, according to the state of the season, from 55 lb. to 66 lb. per imperial bushel; the 55 lb. being very light, and produced in a wet late season on inferior land—the heavy being very heavy, and produced in a hot season on the best soil. An average weight for wheat is 62 to 63 lb. per bushel. The average weight of all the wheat sold in the Edinburgh market in the thirteen years up to 1880 was 62.2 lb. per bushel.[2]

"A plump, rounded, white, smooth grain, without wrinkles, gives the heaviest weight per bushel. Wheat grain is heavier than water, its specific gravity ranging from 1.29 to 1.41."[3]

"High specific gravity is, above all, an indication of good quality. Wheat which weighs 50 to 60 lb. per imperial bushel is considered good—that is, rich in flour. The grains should be equal-sized, large, and full. In rare cases the weight rises to 66 lb. per imperial bushel."[4]

[1] *Kick's Flour Manufacture.*
[2] *A Bushel of Corn*, A. S. Wilson, p. 35.
[3] Church's *Food.*
[4] Powles's *Kick's Flour Manufacture.*

Number of Grains in a Bushel.—Of Chidham white wheat, weighing 65 lb. per bushel, 86 grains were found to weigh one drachm, so that the bushel should contain 715,520 grains. At 63 lb. to the bushel, and 87 grains to the drachm—the most common case—the bushel should contain 701,568 grains.

Wheat for Seed.—For seed, the root-end of the grain should be distinctly prominent, and the stem-end slightly hairy. When either end is rubbed off, the grain is deprived of its vitality. Kiln-drying also destroys vitality. Wheat unfit for seed may be detected in various ways. If it has been in sea-water, although not enlarged by moisture, it never loses the saline taste. When washed in fresh water and dried in a kiln, the washing gives it a bleached appearance, and the kiln-drying is detected by smell or taste. When shealed, the ends are rubbed down. When heated in the sack, it tastes bitter. When heated in the stack, it has a high colour. When long in the granary, it is dull and dirty, and has a musty smell. When attacked by weevils and other insects in the granary, which breed within its shell and eat the kernel, the shells are light, and have holes in them. Germinated, swollen, burst, bruised, smutted grains, and the presence of other kinds of corn and seeds, are easily detected by the eye.

Preserving Wheat in Granaries.—Difference of opinion exists in regard to the best mode of preserving wheat in granaries. The usual practice is to shovel the heap over from the bottom every few weeks, according to the dryness or dampness of the air, or heat or coldness of the atmosphere. In this mode of treatment a free ventilation of air is requisite in the granary, and the worst state of the atmosphere for the grain is when it is *moist* and *warm*. Extreme heat or extreme cold are preservatives of corn.

The practice of others is not to turn it over at all, but to keep it in the dark in thick masses, reaching from the floor to the ceiling. No doubt, if air could be excluded from a granary, the corn would be preserved in it without trouble; and a good plan of excluding the air seems to be, to heap the grain as close together as possible. When kept long in heap

without turning, it retains its colour with the fresh tint, which is also secured by keeping it in the dark.

Ancient Practice in Storing.—The ancients preserved grain many years, to serve for food in years of famine. Joseph, in Egypt, preserved wheat for seven years in the stores; in Sicily, Spain, and the northern parts of Africa, pits were formed in the ground to preserve it; and the Romans took great pains in constructing granaries, which kept wheat for 50 and millet for 100 years.[1]

Storing *v.* Immediate Selling.—The practice of storing grain in farm granaries is not now pursued to so large an extent as formerly; yet it is often found necessary or desirable for the farmer to store a moderate quantity for a limited time. As to this point a cautious and experienced farmer says:—

"As regards the farmer, the question of preserving wheat in granaries should little affect him, the best way of keeping wheat being in the straw in the stack; and when the stacks are threshed, that the straw may be used, he should dispose of his wheat immediately, and take the current market prices. During the currency of a lease, this is the safest practice for securing him an average price; and it saves much trouble in looking after the corn, much vexation when it becomes injured, and much disappointment when the price falls below its expected amount. Loss is likely to be the fate of farmers who speculate in corn of their own growth; and when they become merchants besides, they are likely to become involved in the intricacies of foreign trade, and feel the effects of their thoughtlessness."

Quantity of Ash in an Acre of Wheat.—Lawes and Gilbert found at Rothamsted that the average quantities of total mineral constituents (ash) yielded per acre per annum, over sixteen years on three plots, differently manured, on which wheat was continuously grown, were the following:—

	In grain. lb.	In straw. lb.	Total. lb.
By farmyard manure	36.3	201.1	237.4
Without manure .	16.6	89.5	106.1
With ammonia salts alone . . .	23.0	119.2	142.2

[1] Dickson's *Hus. Anc.*, ii. 426.

Kernel and Husk.—Mr A. S. Wilson found that of the grain of wheat about 95.59 per cent consisted of kernel, and 4.41 per cent of husk.

Origin of Wheat.—"It is a very remarkable circumstance," observes Lindley, "that the native country of wheat, oats, barley, and rye should be entirely unknown; for although oats and barley were found by General Chesney, apparently wild, on the banks of the Euphrates, it is doubtful whether they were not the remains of cultivation. This has led to an opinion, on the part of some persons, that all our cereal plants are artificial productions, obtained accidentally, but retaining their habits, which have become fixed in the course of ages.[2]

Antiquity of Wheat Cultivation.—A. de Candolle[3] observes that the cultivation of wheat is prehistoric in the Old World. Very ancient Egyptian monuments, older than the invasion of the shepherds, and the Hebrew Scriptures, show this cultivation already established; and when the Egyptians or Greeks speak of its origin, they attribute it to mythical personages—Isis, Ceres, Triptolemus. The earliest lake-dwellers of Western Switzerland cultivated a small-grained wheat, which Heer has described under the name of *Triticum vulgare antiquorum.* The first lake-dwellings of Robenhausen were at least contemporaneous with the Trojan war, and perhaps earlier. The Chinese grew wheat 2700 B.C.

Limits of Wheat Culture.—Only the lower-lying parts of the United Kingdom are well suited for wheat cultivation, yet at one time or other wheat has been grown to a greater or lesser extent in every county in England and Wales, and also in most counties in Scotland.

"Wheat is cultivated in Scotland to the vicinity of Inverness (lat. 58°); in Norway to Drontheim (lat. 64°); in Sweden to the parallel of lat. 62°; in western Russia to the environs of St Petersburg (lat. 60° 15′); while in central Russia the polar limits of cultivation appear to coincide with the parallel of 59° or 60°. Wheat is here almost an exclusive cultivation, especially in a zone

[2] Johnston's *Lect. Agric. Chem.*, 2nd ed., 928.
[3] Lindley's *Veget. King.*, 112.

which is limited between the latitude of Tchernigov, lat. 51°, and Ecaterinoslav, lat. 48°. In America the polar limits of wheat are not known, on account of the absence of cultivation in the northern regions. The physical conditions of these limits are, in the different countries where cultivation has been carried to the utmost extent, as follows:—

	Lat.	Mean temperature, Fahr. Year.	Winter.	Summer.
Scotland (Ross-shire)	58°	46°	35°	57°
Norway (Drontheim)	64	40	25	59
Sweden . . .	62	40	25	59
Russia (St Petersburg)	60 15′	38	16	61

This table shows how little influence winter cold has in arresting the progress of agriculture towards the north; and this is confirmed in the interior of Russia, where Moscow is much within the limits of wheat. The cultivation of wheat is very productive in Chili, and in the united state of Rio de la Plata. On the plateau of southern Peru, Meyer saw most luxurious crops of wheat at a height of 8500 feet, and at the foot of the volcano of Arequipo, at a height of 10,600 feet. Near the lake of Tabicaca (12,795 feet high), where a constant spring-heat prevails, wheat and rye do not ripen, because the necessary summer-heat is wanting; but Meyer saw oats ripen in the vicinity of the lake."[1]

Barley.

The botanical position of *barley* is the genus *Hordeum*, of the natural order of *Graminece*. Professor Low divides the cultivated barleys into two distinctions,—namely, the 2-rowed and the 6-rowed, and these comprehend the ordinary, the naked, and the sprat or battledore forms.[2] Lawson describes 20 varieties of barley.[3]

Classifying by the Ear.—The natural classification of barley by the ear is obviously into three kinds—4-rowed, 6-rowed, and 2-rowed. Fig. 404 represents the three forms, where *a* is the 4-rowed, or bere or bigg, *c* the 6-rowed, and *b* the 2-rowed, which figures give the ear in half its natural size. Of these the bere or bigg was cultivated until a recent period, but the 2-rowed has almost entirely supplanted it, and become the most commonly cultivated variety, the

Fig. 404.

4-rowed bere or bigg. *6-rowed barley.* *2-rowed barley.*

6-rowed being rather an object of curiosity than culture.

Classifying by the Grain.—In classifying barley by the *grain* we find there are just two kinds, *bere* or *bigg*, and *barley;* and though both are awned, they are sufficiently marked to constitute distinct varieties. In the bere, fig. 405,

Fig. 405.—*Scotch bere or bigg.*

Fig. 406.—*English barley.*

the median line of the bosom is so traced as to give the grain a twisted form, by which one of its sides is larger than the other, and the lengthened point is from where the awn was broken off. The figure gives the grain of the natural size.

In barley, fig. 406, the median line passes straight, and divides the grain into two equal sides, short and plump,

[1] Johnston's *Phys. Atl.*—Phytol., Map No. 2.
[2] Low's *Ele. Prac. Agric.*, 244.
[3] Lawson's *Agric. Man.*, 33.

with a crenulated skin. The grain here is of the natural size. The bigg was long cultivated in Scotland, along with a 2-rowed variety named common or Scotch barley; but several English varieties are now cultivated which show a brighter and fairer colour, plumper and shorter grain, and are quicker in malting, though less hardy and prolific, than the common barley.

A variety known as *awnless* barley is now cultivated. When it becomes fully ripe the awns fall off, hence its name.

Judging Barley.—The crenulated skin is a good criterion of malting; and as most of the barley is converted into beer or spirits, both requiring malt to produce them of the finest quality, it is not surprising that English Chevalier barley should realise the highest price. In judging good barley it should break soft between the teeth, and show a white fracture, and be wrinkled in the bosom. When it breaks hard it is flinty, and will not malt well.

As to grinding barley, "the indications of good flour-producing qualities in barley are these: a fine pale-yellow colour, roundish rather than long form, and a high specific weight. Long, pointed, and flat grains yield less flour, and of a bluish tint. According to Neumann, barley one year old will yield flour whiter than fresh barley."[1]

Yield and Weight of Barley.—A good crop of barley yields a return of from 48 to 60 bushels per acre. Good barley weighs from 54 lb. to 59 lb. per bushel. A crop of 60 bushels per acre will yield of straw about 176 stones of 14 lb. to the stone, or $1\frac{1}{10}$ ton, and the weight of the grain of that crop, at 56 lb. per bushel, will be $1\frac{1}{2}$ ton. Mr A. S. Wilson states that the average weight of all the barley sold in the Edinburgh market in the thirteen years ending with 1880 was 54.93 lb. per bushel, the range being from 46 to 60 lb.[2]

Grains in a Bushel.—It takes of bigg 111 grains to weigh one drachm; of 6-rowed barley, 93; and of Chevalier barley, 75 grains; of which, with the weight per bushel of 57 lb., the number of grains of Chevalier barley in a bushel will be 547,200.

About 90 per cent of the grain of barley consists of kernel, and 10 per cent of husk.

Utilisation of Barley.—By far the largest proportion of the best barley is converted into *malt* for making malt liquor and spirits. Barley is also used for distillation in the raw state.

Pot and pearl barley are made from barley for culinary purposes. Both meal and flour are manufactured from barley for making unleavened bread, which is eaten by the labouring class in some parts of the country.

Of the states of barley the soft is best adapted for making into malt and meal, and the flinty into pot barley. It was supposed that flinty barley contained the most gluten or nitrogen; but Professor Johnston showed that it contains less than the soft barley, in the proportion of 8.03 to 10.93.

Barley-meal.—"The meal so highly commended by the Greeks was prepared from barley. . . . It was not until after the Romans had learnt to cultivate wheat, and to make bread, that they gave barley to the cattle. They made barley-meal into balls, which they put down the throats of their horses and asses, after the manner of fattening fowls, which was said to make them strong and lusty. Barley continued to be the food of the poor, who were not able to procure better provision; and in the Roman camp, as Vegetius has informed us, soldiers who had been guilty of any offence were fed with barley instead of bread corn."[3]

Malting.—The malting of barley for use as food for live stock will be noticed in the section dealing with "Food and Feeding."

Limits of Barley Culture.—Barley is not found to be a profitable farm crop so far north as oats, but occasionally it is grown in small areas in Orkney and Shetland (lat. 61° N.) In Western Lapland the limit of barley is under lat. 70° near Cape North, the northern extremity of Europe. In Russia, on the shores of the White Sea, it is between the parallels of 67° and 68° on the western side, and

[1] Kick's *Flour Manufacture.*
[2] *A Bushel of Corn.*
[3] Phillips's *Hist. Culti. Veget.*, i. 50.

about 66° on the eastern side, beyond Archangel; in central Siberia, between lat. 58° and 59°.

Between the tropics barley does not succeed in the plains, because of its liability to suffer from heat.

Oats.

The oat-plant belongs to the natural order of *Gramineæ*, genus *Avena*. Its ordinary botanical name is *Avena sativa*, or cultivated oat. The term oat is of obscure origin. Paxton conjectures it to have been derived from the Celtic *etan*, to eat.[1]

There are a great number of varieties of this cereal cultivated in this country. Lawson describes thirty-eight.[2]

Classification by the Grain.—The natural classification of the oat by the grain consists only of two forms—one plump and short and beardless, as fig.

Fig. 407.—*Potato oat.*

Fig. 408.—*White Siberian early oat.*

407, the potato oat, smooth-skinned, shining, having the base well marked, and the germ-end short and pointed.

The other form is in fig. 408, long and thin, and having a tendency to produce a beard, the white Siberian early oat. It is cultivated in the poorer soils and higher districts, resists the force of the wind, and yields a grain well adapted for the support of farm-horses.

The straw is fine and pliable, and makes an excellent dry fodder for cattle and horses, the saccharine matter in the joints being very sensible to the taste. It comes early to maturity, and hence its name.

Mr A. S. Wilson divided oats into three groups, which he designated as the *Oviform*, *Coniform*, and *Fusiform*. In the first he placed the short round oats approaching the form of an egg, the potato oat and Scots barley oat being types of this class. The *Coniform* embraced the oats of medium length in proportion to their thickness, as the sandy oat. The long oats, such as the Tartarian and Arkangel oats, comprised the *Fusiform*.[3]

Classification by the Ear.—The natural classification of the oat by the ear is obvious. One kind, fig. 409, has its branches spreading equally on all sides, shortening gradually towards the top of the spike in a conical form, and the panicles are beardless. This is the potato oat. While the ear is yet recent, the branches are erect; but as the seeds advance towards maturity, and become full and heavy, they assume a dependent form. By this change, the air and light have free access to the ripening grain, while the rain washes off the eggs or larvæ of insects that would otherwise prey upon the young seed. This variety is extensively cultivated in Scotland on account of the fine and nourishing quality of its meal, which is largely consumed by the people—unfortunately not so largely now as in former times. It is cultivated in the richer soils of the low country.

Fig. 409.—*Spike of potato oat.*

The plant of the potato oat is tender, and the grain is apt to be shaken out by the wind. The straw is long and strong, inclining too much to reediness to make good fodder. It is late in coming to maturity. Its peculiar name of the potato oat is said by one writer to have been derived from the circumstance of the first

[1] Paxton's *Bot. Dict.*, art. Avena.
[2] Lawson's *Agric. Man.*, 44.
[3] *A Bushel of Corn.*

plants having been discovered growing accidentally on a heap of manure, in company with several potato-plants, the growth of which was equally accidental;[1] while another writer says plants of it were first found in 1789 in Cumberland, growing in a field of potatoes. The ear in the figure was taken from the stack, none being at the time available in the field, where it would have been more regular and beautiful.

The white Siberian oat, fig. 408, has an ear of this description.—The other kind of ear has its panicles shorter, nearly of equal length all on the same side of the rachis, and bearded.

Fig. 410.—*Spike of Tartarian oat.*

Fig. 410, a head of Tartarian oat, taken from the stack, shows this form of ear. The seeds of this form also assume the pendant position. It is of such a hardy nature as to thrive in soils and climates where other oats could not be raised. This variety derives its name, most probably, from Tartary. It is much cultivated in England, and only to a limited extent in Scotland. It is a coarse grain, more suitable for animal food than for making into meal. The grain is dark-coloured, awny; the straw coarse, harsh, brittle, and rather short.

Yield and Weight of Oats.—The *crop* of oats varies from 30 to 80 bushels per imperial acre, according to kind, soil, and situation, 40 to 48 being very general. Oats vary in weight from 33 lb. to 48 lb. per bushel. The average of all the oats sold in the Edinburgh market during a period of thirteen years was 42.22 lb. per bushel. Whiteness, of a silvery hue, and plumpness, are the criteria of a good sample. A crop of potato oats, yielding 60 bushels to the acre, at 47 lb. per bushel, weighs of grain 1 ton 5 cwt. 20 lb., and yields of straw 1 ton 5 cwt. 16 lb., in the neighbourhood of a large town; or, in other words, yields 8 kemples of 40 windlings each, and each windling 9 lb. in weight. A crop of Hopetoun oats, of no more than 60 bushels to the imperial acre, grown near Edinburgh, yielded 2 tons 18 cwt. 16 lb. of straw.

Grains in the Bushel.—The potato oat, 47 lb. per bushel, gave 134 grains to one drachm; the Siberian early oat of 46 lb. gave 109 grains; and the white Tartarian oat, 42 lb., gave 136 grains; so that these kinds respectively afford 806,144,651,792, and 731,136 grains of oats per bushel.

Kernel and Husk.—Mr A. S. Wilson gave the proportions of kernel and husk in the old varieties of oats as follows: *Oviform*—kernel 76.34, husk 23.66 per cent; *Coniform*—kernel 76.07, husk 23.93; and *Fusiform*—kernel 73.23, and husk 26.77 per cent. Average of all kinds—kernel 75.21, and husk 24.79 per cent.[2] In the new varieties of oats the percentage of husk is greater—often as much as 37 per cent.

Oatmeal.—For human food the oat is manufactured into *meal*, not into flour. Oats are always kiln-dried before being ground, in order the more readily to get quit of the thick husk in which the grain is enveloped. After the husk has been separated by a fanner, the grain, then called groats, is ground by the stones closer set, and yields the meal. The meal is then passed through sieves, to separate the thin husk from the meal. The meal is made into two states: one *fine*, which is the state best adapted for making into oat-cake or bannocks; and the other is coarser or *rounder* ground, which is best adapted for making the common food of the country people—

[1] Rhind's *Hist. Veget. King.*, 218.

[2] *A Bushel of Corn.*

porridge,—*Scottice*, parritch. A difference of custom prevails in respect to using these two different states of oatmeal, the fine meal being best liked for all purposes in the northern, and the round meal for porridge in the southern, counties.

There is, unfortunately, too good reason to fear that this wholesome article is losing its position as the "common food" of the country people of Scotland. Meat, fish, and milk food are now consumed much more largely by the rural classes of Scotland than in former times; and the "cheap loaf" is fast supplanting the more substantial oat-cake.

A sharp soil produces the finest cake-meal, and clay land the best meal for boiling. Of meal from the varieties of the oat cultivated, that of the common Angus oat is the most thrifty for a poor man, though its yield in meal is less in proportion to the bulk of corn.

Oatmeal was for long the principal food of the Scottish ploughman. In most parts it is still largely consumed by them, but it is now used to a smaller and gradually decreasing extent. It was considered a rather anomalous circumstance to find men thriving as well on oatmeal as on wheat bread and butcher-meat; but the anomaly was cleared up by the investigations of chemistry. The oat contains about 7 per cent of oil or fat, and 12 per cent of protein, making together nearly 20 per cent of really nutritive matter, capable of supporting the loss incurred by labour of the muscular portion of the body. All vegetables contain fat, and the largest proportion of vegetable fats contain the elaic and margaric acids, mixed with a small proportion of the stearic. The elaic is always in a fluid state, and the margaric and stearic in a solid; and of the latter two, the margaric is much less, and the stearic acid very much greater, in animal fat than in those of plants. It is by the dissipation of this oil or fat by heat, in baking, that the agreeable odour of the oat-cake is at once recognised on approaching the humble cottage of the labouring man.

Yield of Meal.—In regard to the *yield of meal* from any given quantity of oats, when they give half their weight of meal they are said to give *even meal*. Supposing a boll of oats of 6 bushels to weigh 16 stones, it should give 8 stones or 16 pecks of meal, and, of course, 8 stones of refuse, to yield even meal. But the finer class of oats give more meal in proportion to weight than this—some nearly 9 stones and others as much as 12 stones per boll. The market value of oats is therefore often estimated by the meal they are supposed to yield, and in discovering this property in the sample millers become very expert.

Composition of Oatmeal.—The following figures give an approximation of the percentage composition of fresh Scotch oatmeal:—

Water	10.5
Albuminoids	11.0
Carbohydrates	52.2
Fats	4.5
Fibre	14.5
Ash	6.8

One hundred pounds of oats (weighing 45½ lb. to the bushel) commonly yield the following proportion of products:—

	lb.
Oatmeal	60
Husks	26
Water	12
Loss	2

Kick,[1] quoting the mean of many analyses, gives for oats the following percentage composition:—

Starch	56
Gluten	12
Cellulose	12
Salts	3
Water	17

Oats as Food for Stock.—Oats are now used much more extensively than formerly as food for horses, cattle, and sheep. Indeed this is now their chief function. For this purpose they are usually crushed flat.

Antiquity of Oat Culture.—"We find no mention made of oats in Scripture," says Phillips, "which expressly states that Solomon's horses and dromedaries were fed with barley;" but "the use of oats as a provender for horses appears to have been known in Rome as early as the Christian era, as we find

[1] *Flour Manufacture.*

that that capricious and profligate tyrant, Caligula, fed 'Incitatus,' his favourite horse, with *gilt oats* out of a golden cup." Oats are mixed with barley in the distillation of spirits from raw grain; and "the Muscovites make an ale or drink of oats, which is of so hot a nature, and so strong, that it intoxicates sooner than the richest wine." [1]

Origin of the Oat.—As all the varieties of oats are cultivated, and none have been discovered in a truly wild state, it is very probable that they are all derived from a single prehistoric form, a native of eastern temperate Europe and of Tartary (A. de Candolle).

Limits of Oat Culture.—"The oat (*Avena sativa*) is cultivated extensively in Scotland, to the extreme north point, in lat. 58° 40′. In Norway its culture extends to lat. 56°; in Sweden to lat. 63° 30′. In Russia, its polar limits appear to correspond with those of rye. Whilst, in general, oats are cultivated for the feeding of horses, in Scotland and in Lancashire they form a considerable portion of the usual food of the people. This is also the case in some countries of Germany, especially in the south of Westphalia, where the inhabitants of the 'Sauerlands' live on oaten bread. South of the parallel of Paris oats are little cultivated; in Spain and Portugal they are scarcely known; yet they are cultivated with considerable advantage in Bengal to the parallel of lat. 25° N." [2]

Rye.

Rye, botanically, occupies the genus *Secale* of the order *Gramineæ*. It is the *Secale cereale* of the botanists, so called, it is said, from *á secando*, to cut, as opposed to leguminous plants, whose fruits used to be gathered by the hand.

A spike of rye, fig. 411, is not unlike a hungry bearded wheat. There is only one known species of rye, which is said to be a native of Candia, and was known in Egypt 3300 years ago. But several varieties are raised as food, four of which are described by Lawson.[3]

A. de Candolle adduces historical and philological data to show that the species probably had its origin in the countries north of the Danube, and that its cultivation is hardly earlier than the Christian era in the Roman Empire, but perhaps more ancient in Russia and Tartary.

The grains of rye are long and narrow, not unlike shelled oats or groats, but more flinty in appearance. They are in fig. 412, of the natural size.

Rye is rarely cultivated in this country for its grain, but as a green forage crop it is grown to a considerable extent both in the south of England and the south of Ireland. In Scotland only small patches here and there are to be seen. It is extensively cultivated on the Continent, on all soils, and forms the principal article of food of the labouring classes.

Fig. 411.—*Ear of rye.*

"Closely resembling the wheat berry is that of rye. Its appearance is well known as naked, rather long, very tapering off at the lower end, curved or slightly keeled at the back, with a furrow at the front, and with hairs at the upper end. It is of a greyish-brown colour, and slightly wrinkled." [4]

Yield and Weight of Rye.—The produce of rye is about 25 bushels per acre, and the weight of the grain is from 52 to 57 lb. per bushel. The number of grains in 1 drachm being 165, at 55 lb., the bushel should contain 1,161,600 grains.

Fig. 412.—*Grains of rye.*

In a crop of 25 bushels to the acre, weighing 1300 lb., the nutritive matter derived from rye consists of 130 lb. to 260 lb. of husk or woody fibre; 780 lb. of starch, sugar, &c.; 130 to 230 lb. of gluten, &c.; 40 to 50 lb. of oil or fat; and 26 lb. of saline matter.

Limits of Rye Culture.—"Rye (*Secale cereale*) is cultivated in Scandinavia, on the western side to the parallel of 67° N., and on the eastern side to lat. 65° or 66° N. In Russia, the

[1] Phillips's *Hist. Culti. Veget.*, ii. 9.
[2] Johnston's *Phys. Atl.*—Phytol., Map No. 2.
[3] Lawson's *Agric. Man.*, 31.
[4] Kick's *Flour Manufacture.*

polar limit of rye is indicated by the parallel of the city of Jarensk, in the government of Wologda, lat. 62° 30′. . . . It is as common in Russia, Germany, and some parts of France, as it is rare in the British Islands. Rye-bread still forms the principal sustenance of at least one-third of the population of Europe; it is the characteristic grain of middle and northern Europe; in the southern countries it is seldom cultivated." [1]

Rye is much used in the distillation of gin in Holland. Rye-bread is heavy, dark-coloured, and sweet, but when allowed to ferment, becomes sour.

Rye-flour.—In Russia, 100 lb. of rye-flour, containing 16 per cent of water, yield from 150 lb. to 160 lb. of bread. There, horses get it on a journey, in lieu of corn. The following indicates the percentage proportion of water, albuminoids, fats, carbohydrates, fibre, and ash in rye-flour:—

Water	12.0
Albuminoids	13.6
Fats	2.9
Carbohydrates	63.2
Fibre	4.2
Ash	4.1
	100.0

STRAW.

The straw of the various farm crops presents marked differences in appearance and composition.

Wheat-straw.

Wheat-straw is generally long, often upwards of 6 feet in length, and most kinds are strong. Of the two sorts of wheat, white and red, the straw of the white is softer, more easily broken by the threshing-mill, and decomposed in the dunghill. Red wheat-straw is tough, and is used for stuffing horse-collars. The strength and length of wheat-straw render it useful in thatching, whether houses or stacks. It is yet much employed in England for thatching houses, and perhaps the most beautifully thatched roofs are in the county Devon, whilst excellent examples of this art may be seen in Wiltshire.

Since the general use of slates in Scotland, thatching houses with straw has fallen into desuetude. Wheat-straw makes the best thatching for corn-stacks, its length and straightness ensuring safety, neatness, and despatch, which, in the busy period of securing the fruits of the earth, is valuable. It forms an admirable bottoming to the littering of every court and hammel of the steading. As litter, wheat-straw possesses superior qualities, and few gentlemen's stables are without it.

It is not so well suited for fodder, its hardness and length being unfavourable to mastication; yet farm-horses are fond of it when it is fresh.

Upholsterers use wheat-straw as stuffing in mattresses for beds, under the name of *paillasse;* but such a mattress is a miserable substitute for crisp, curled, elastic horse-hair.

Ash of Wheat-straw.—The ash of wheat-straw contains the following ingredients:—

	Berthier.	Boussingault.	Fromberg.
Potash	10.86	9.56	15.52
Soda	...	0.31	...
Lime	5.36	8.83	4.58
Magnesia	...	5.19	2.45
Oxide of iron	2.32	1.04	1.56
Phosphoric acid	1.12	3.22	2.92
Sulphuric acid	0.44	1.04	10.59
Chlorine	2.82	0.62	1.56
Silica	77.08	70.19	60.58
	100.00	100.00	99.76
Percentage of ash	4.40	7.00	

In Fromberg's analysis silica is deficient, and sulphuric acid abundant.

The following figures show the mean results of analyses of the ash of wheat-straw, grown under ten different conditions as to manuring, during two consecutive periods of ten years each, by Sir J. B. Lawes and Dr Gilbert, at Rothamsted:—

	10 years. 1852-61.	10 years. 1862-71.
Pure ash	55.6	55.6
Ferric oxide	0.32	0.22
Lime	2.86	3.50
Magnesia	0.81	1.03
Potash	11.19	10.46
Soda	0.23	0.34
Phosphoric acid	1.75	1.77
Sulphuric acid	2.42	2.25
Chlorine	1.95	2.17
Silica	34.48	34.28

These figures show the quantity of each ash-constituent per 1000 dry substance of straw.

[1] Johnston's *Phys. Atl.*—Phytol., Map No. 2.

Barley-straw.

Barley-straw is soft, has a clammy feel, and its odour, with its chaff, when newly threshed, is heavy and malt-like.

As will be shown in the section dealing with the different varieties of foods, barley-straw is not much relished by live stock, but cut into chaff it is used to a considerable extent in pulped mixtures for cattle. It does not make a good thatch for stacks, being too soft and difficult to assort in lengths, apt to let through the rain, and rot.

Ash.—The ash of barley-straw contains these ingredients:—

	Boussingault.	Sprengel.
Potash	9.20	3.43
Soda	0.30	0.92
Lime	8.50	10.57
Magnesia	5.00	1.45
Oxide of iron and a little oxide of manganese	1.00	0.65
Alumina	...	2.78
Phosphoric acid	3.10	3.06
Sulphuric acid	1.00	2.25
Chlorine	0.60	1.33
Silica	67.60	73.56
	96.30	100.00
Percentage of ash	7.00	5.24

Strength of Straw.—"There exists a popular notion that strength of straw is dependent on a high percentage of silica; but direct analytical results clearly show that the proportion of silica is, as a rule, lower, not higher, in the straw of the better-grown and better-ripened crop—a result quite inconsistent with the usually accepted view, that high quality and stiffness of straw depend on a high amount of silica. In fact, high proportion of silica means a relatively low proportion of organic substance produced. Nor can there be any doubt that strength of straw depends on the favourable development of the woody substance; and the more this is attained the more will the accumulated silica be, so to speak, diluted—in other words, show a lower proportion to the organic substance."[1]

Oat-straw.

Oat-straw is used mostly as fodder, being too valuable for litter.

[1] Fream, *The Rothamsted Experiments on Wheat, Barley, &c.*

Ash.—The composition of the ash of oat-straw is as follows:—

	Levi. Kurhess.	Boussingault. Alsace.
Potash	12.18	26.09
Soda	14.69	4.69
Lime	7.29	8.84
Magnesia	4.58	2.98
Oxide of iron	1.41	2.24
Phosphoric acid	1.94	3.19
Sulphuric acid	2.15	4.37
Chlorine	1.50	5.00
Silica	54.25	42.60
	99.99	100.00
Percentage of ash	5.10	

Chaff as a Foot-warmer.—The chaff of all the cereals is an admirable conserver of heat. Poachers in Scotland, when sitting out in winter nights in wait for ground-game, have effectually kept their feet from getting cold by letting them lie in a bag containing dry chaff. A bag of chaff may not be a convenient, but it is certainly a most effective, foot-warmer.

Rye-straw.

Rye-straw is small, hard, and wiry, quite unfit for fodder, and would be an unmanageable litter in a stable, though useful in a court, in laying a durable bottoming for the dunghill. It makes excellent thatch for stacks. It is much sought for by saddlers for stuffing collars of posting and coach horses. It is also in great request by brickmakers. Bottles of Rhine wine are packed in rye-straw.

Rye-straw is sometimes three or four times as heavy as the grain, which is a remarkable feature in this straw.

The plaiting of rye-straw into hats was practised as long ago as the time of the ancient Britons. Bee-hives and *ruskies*—baskets for supplying the sowers with seed—are beautifully and lightly made of rye-straw.

The ash of rye-straw contains these ingredients:—

	Will and Fresenius.
Potash	17.36
Soda	0.31
Lime	9.06
Magnesia	2.41
Oxide of iron	1.36
Phosphoric acid	3.82
Sulphuric acid	0.83
Chlorine	0.46
Silica	64.50
	100.11

Percentage of ash, about 4.

Ash of Straw.—100 lb. of the *ash* of the above sorts of straw gave the following weights of these constituents:—

Constituents.	Wheat-straw.	Barley-straw.	Oat-straw.	Rye-straw.	Bean-straw.	Pea-straw.
	lb.	lb.	lb.	lb.	lb.	lb.
Potash	0½	3½	15	1	53½	4¾
Soda	0¾	1	a trace	0½	1½	..
Lime	7	10½	2¾	6	20	54¾
Magnesia	1	1½	0½	0½	6½	6¾
Alumina	2¾	3	a trace	1	0¼	1¼
Oxide of Iron	..	..	..			0½
Oxide of manganese	..	0½	a trace	..	0¼	0¼
Sulphuric acid	1	2	1½	6	1	6¾
Phosphoric acid	5	3	0¼	2	7¼	4¾
Chlorine	1	1½	a trace	0¾	2¾	0¼
Silica	81	73½	80	82¼	7	20
	100	100	100	100	100	100

On comparing these numbers, one cannot fail to remark the large proportion of potash in bean-straw; the trace of soda in all the straws except the pea; the large proportion of lime in pea-straw compared with bean-straw; the large proportion of silica in wheat- and oat-straw compared with pea-straw and bean-straw; and the large proportion of phosphoric acid in bean-straw compared with oat-straw.

Yield of Straw.—The value of straw may be estimated from the quantity usually yielded by the acre, and the price which it realises. Arthur Young estimated the straw yielded by the different crops—but rejecting the weaker soils—at 1 ton 7 cwt., or 3024 lb. per English acre. Mr Middleton estimated the different crops in these proportions:—

	cwt.	lb.	
Wheat-straw	31	or 3472	per acre.
Barley "	20	2240	"
Oat "	25	2800	"
Bean "	25	2800	"
Pea "	25	2800	"
Average rather more than	25	2822	

or 1 ton 5 cwt. 22 lb. per English acre. In the immediate vicinity of Edinburgh, the produce, both in Scotch and imperial measures, per acre, has been found to be as follows:—

				Stones.	lb.	ton.	cwt.	lb.
Wheat-straw,	9 kemples of	16 st.	of 22 lb.	=144	or 3168	or 1	8	32
Barley	7 "	"	"	=112	2464	1	2	0
Oat	8 "	"	"	=128	2816	1	5	16
Average	8 "	"	"	=128	2816	1	5	16

or 1 ton 5 cwt. 16 lb. per Scotch, or 1 ton 0 cwt. 3 lb. per imperial, acre.

Ancient Uses of Straw.—The Romans used straw as litter, as well as fodder, for cattle and sheep. They considered millet-straw as the best for cattle, then barley-straw, then wheat-straw. This arrangement is rather against our ideas of the comparative qualities of barley and wheat-straw; but the hot climate of Italy may have rendered the quality of barley-straw better, by making it drier and more crisp, and the wheat-straw too hard and dry. The haulm of pulse was considered best for sheep. They sometimes bruised straw on stones before using it as litter, which is analogous to having it cut with the straw-cutter. Where straw is scarce, they recommend the gathering of fern, leaves, &c., which is a practice that may be beneficially followed in this country, where opportunity occurs. Varro says, "It is the opinion of some that straw is called *stramentum*, because it is strawed before the cattle."[1]

[1] Dickson's *Husb. Anc.*

Straw as food for stock will be dealt with in the section of this work entitled "Food and Feeding."

CROSS-FERTILISATION OF GRAIN.

The following notes on the cross-fertilisation of grain have been prepared for this work by Mr John Speir.

Degeneracy of Grain.—Most varieties of fixed types of plants appear to degenerate or become weakly after having been subjected, for a number of years, to the forcing influences of modern cultivation. Comparatively speaking, indeed, only a short time elapses between their introduction and the time when they commence to show signs of decay. With the grains this is in part averted by repeatedly and continuously using seed grown in some different locality, so that their rate of degeneration is slow in proportion to that of some other farm crops—potatoes, for instance.

As a rule, however, new varieties of grain, if otherwise good, are more vigorous in growth than most old ones, and in consequence their production is a matter of great importance to the arable farmer. The grains have not been improved to an equal extent with most other farm crops.

Mr Knight's Efforts.—Previous to the middle of the nineteenth century most of the new varieties of grain were natural crosses or sports, which were perpetuated and increased by selection. It appears that Mr Knight, a celebrated horticulturist who lived during the latter half of the eighteenth century, introduced a considerable number of new varieties of grain; but although he was aware how cross-breeding was done, it is unlikely that he obtained any of the varieties he introduced by directly crossing them. His method of procedure was to grow a number of varieties together, in the hope that a favourable natural cross might be produced. In this way he was able to introduce several new varieties, which were of such a strong constitution that, during the years 1795 and 1796, when most grain in this country was blighted, the varieties thus obtained are said to have more or less escaped.

Mr Raynbird's Experiments.—In 1851 Mr Raynbird and Mr Maund showed ears of cross-bred wheats at the great International Exhibition held in London in that year. These are supposed to be the first direct cross-bred grains which were ever offered to the public; and although many of them were considered more as curiosities than anything else, still one of them attained considerable popularity as Raynbird's Hybrid in after-years.

Mr P. Shirreff's Experiments.—About this date Mr Patrick Shirreff of Haddington commenced his experiments in cross-breeding and selection. In the twenty years or so during which he persevered in the work, he succeeded in introducing several new varieties; but although he may be considered the first methodical cross-breeder of grain, he still says he was as successful in getting new varieties from mixtures by natural crossing as from those directly fertilised.

Other Experiments.—About the year 1882 Mr Sharman, of the firm of Messrs James Carter & Sons, London, commenced experiments in the cross-breeding of wheats, which have been attended with a good deal of success. These experiments have been since carried on, and several new varieties have been offered to the public, most of which, as far as appearance of the grain is concerned, look well. All more or less differ in character, some having long straw, and some short. Others have slender straw, while many are stout; some are very early, while others ripen about the usual time. Messrs E. Webb & Sons, Wordsley, Stourbridge, also carried out extensive experiments upon the cross-breeding of grain, and here again considerable success has been attained.

Process of Cross-fertilisation.

In regard to the cross-breeding of grain it may be mentioned that in the vegetable world, as well as among animals, there is a male and female, and the process consists in fecundating the female of one variety with material called pollen taken from the male of another. The process, although a little delicate, is not by any means difficult, and to carry it out does not require any special training in, or knowledge of, botany.

Organs of Fructification.—The accompanying sketch, fig. 413 (for the use of which we are indebted to Messrs A. & C. Black), represents the organs of fructification, much enlarged, of a spikelet of wheat, the chaff-scales having been removed for the sake of convenience. The round part, *o*, is the ovary, and what ultimately becomes the grain; the feathery parts, *s*, are the two styles, or female portions of the flower; while *e* represents the three stamens, or male portions of the flower. The tops of stamens are called anthers, while the tops of the styles are called stigmas. In all the grains the organs of fructi-

Fig. 413.—*Organs of fructification in wheat.*

fication are very much alike, so that what is said regarding one, as a rule will apply to all. For the purpose of effecting cross-fertilisation of any variety, the anthers, *e*, are cut away before they are old enough to have deposited any pollen on the stigmas. If such has happened, cross-fertilisation cannot be effected, and all labour in that direction will be lost.

Details of the Process.—As wheat is perhaps the easiest of all the grains to fertilise artificially, a description of the process, as applied to it, may be given. A variety having been selected, the stigmas of which it is desired to impregnate with the pollen-dust from the anthers of some other variety, the ear is taken as soon as it comes out of the sheath, and all the seed-vessels or spikelets are cut off except one, two, or three. This mutilation of the ear assists considerably the future operations, and if more than one seed-vessel is left on each ear, they should be left as far apart as possible. An ear is now procured of the variety which it is intended to use as a male parent, and which, if possible, should be from four to six days out of the sheath, while the ear which has been prepared, and on which it is intended to operate, should not be over two days out of the sheath, otherwise risk of self-fertilisation will be run.

For convenience in carrying out successfully the delicate process of fertilisation, the operator should provide himself with a very small pair of forceps, so as to be able readily to pluck out the anthers from the one flower, and lift up those of the other. These may be made of a strip of thin steel, brass, or tin, about a couple of inches long, and quarter of an inch wide. Both ends of this strip are narrowed to about one-sixteenth of an inch broad at the points, the strip being then carefully bent over a lead pencil placed at the middle, while the two points are brought together and held in position by the finger and thumb. The ear, which it is intended to make the male parent, is then taken, and the spikelet gently opened by pressing the point of one of the fingers on the tips of the glumes, *B*, and palea, *A* (chaff), fig. 414. The chaff-scales having been thus opened, the anthers, *e*, will be exposed to view. The slender stems which support these are called filaments, which the operator now takes hold of with the forceps, and plucks out, laying each on a sheet of paper in order to be readily taken hold of again when required.

Enough anthers having been procured, the prepared ear, which it is intended to make the female parent, is taken, the chaff-scales *very carefully opened* as already described, and the anthers plucked out. If both ears have been taken at the proper stage, the anthers of the one which it is intended to make the female parent will present a decided greenish tint, while the others will be more of a cream colour.

In plucking the anthers from the female parent, care should be taken to

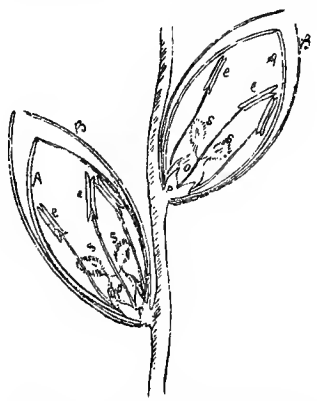


Fig. 414.—*Organs of fructification in wheat.*

catch them by the *filaments only*, otherwise, if caught by the anthers (if too ripe), a portion of the pollen might be shed on the stigmas, causing self-fertilisation. While the chaff-scales are being held open with the one hand, the anthers on the sheet of paper should be caught by the forceps, and dropped on the top of the stigmas, the chaff-scales or palea being then *very carefully closed*. In putting in the anthers, they are none the worse, but all the better, of being caught and pressed by the forceps, as if nearly ripe this forces out the pollen, there being no occasion to catch them by the filament, as when taken out.

In the most of cases it will be found fully as easy to convey the pollen from the one plant to the other by a small

fine-haired brush. This is first drawn several times across a ripe anther, and in the process a considerable amount of pollen adheres to the brush. The brush is now gently passed over the stigmas, and in doing so sufficient pollen is generally left to fertilise them. If an anther is quite ripe, pressure by the forceps is sufficient to cause the case to burst and the pollen to be shed on the stigma; and if everything is in proper condition, as good results will probably be obtained from this method as from any of the others.

Care should, however, be taken not to bruise the feathery stigmas, otherwise fertilisation will not proceed. If the flowering glumes or chaff-scales are *not most accurately closed*, damp gets in and rots the feathery portion of the stigma, thus preventing fertilisation.

The pollen-dust retains its fertilising properties for several days, so that, although the female parent is not ripe enough for fecundation when the operation is performed, it becomes so very soon after, and long before the pollen-dust becomes useless.

After fertilisation the ear should be securely tied to a stake and labelled with the names of both parents.

Time of Natural Fecundation.—It is a general belief among farmers that the grain is being fecundated when the anthers—or bloom, as it is called—appear on the outside of the ear. Such, however, is not the case, as fecundation has already been carried out, the expulsion of the anthers being an effort of nature to rid herself of what is now so much useless material, and the presence of which might interfere with the formation of the grain. The plant opens the chaff-scales and thrusts these out in good weather only, and as soon as they fall off by decay, or are broken off by the wind, the flowering glumes are again closed.

Good Weather Essential.—At this stage of the life of the plant, good weather appears to be necessary, not for the fertilisation of the plant, as has generally been supposed, but to prevent damp getting inside the glumes at the time they are partially opened to get clear of the anthers. The farmer's idea, that good weather is necessary at this stage to ensure a full crop, is thus well founded, although its effect is slightly different from what it is popularly supposed to be.

Period for Crossing.—In order to prolong the period during which crossing may be successfully carried on, a portion of the plants with which it is intended to operate should be cut over near to the ground before and after the stalks are formed, which has the effect of producing a late crop of ears. In this manner the period of crossing may at least be doubled.

First Year usually Unsatisfactory.—Seeds of grain which are produced by artificial crossing have a habit of always presenting themselves the first year in anything but a pleasing form. Whether or not this is brought about by injury to the stigmas or ovary during manipulation, or by the imperfect closing of the chaff-scales, it is difficult to say, so that inexperienced experimenters should not be discouraged when they are in the first year rewarded for their trouble with a badly formed or badly coloured grain, as the next season may quite change its character.

Time Required to Fix Type.—It is at least the second year, and often many years afterwards, before a variety can be obtained true to type. It is at this stage that the Mendelian law comes into force. The single grain which is the result of the first year's cross never produces grain similar to itself. In the following year it may produce from 50 to 100 grains, each of which, although on the one root or on the one stem, may be a different variety. One half of these will generally be permanent, and will produce grain true to their kind, but each of the other half will produce grain which will differ as much from each other in the following year as each seed in the ear of the first year did from its neighbours. Of those which have fixed characteristics, one-half, or quarter of the whole, will resemble the seed-bearing parent, while the other will take after the pollen-bearing one. A similar percentage of the remaining grains become fixed in the following year, and so on. It is only recently that Mendel's laws became generally understood, and with the aid of this knowledge the work of the hybridiser

will be considerably simplified and lessened.

Percentage of Success.—In a favourable season, and in the hands of an experienced operator, from 25 to 75 per cent of the spikelets operated on may produce grains, while, if the operation is clumsily done, none may be produced.

Protecting the Ears.—As soon, however, as it is seen that the flowers have set, the ears should be encircled by fine wire gauze, or strong muslin, to prevent birds destroying the grain. The operation of crossing, for the sake of convenience, is generally performed near the side of a wheat plot; and the fixing of a stake to each plant is a necessity for identification, and this stake is almost sure to be made a resting-place by the sparrows and other small birds which infest the sides of wheat fields, so that if unprotected many grains are sure to be lost.

After Culture.—When the grains are ripened and thoroughly dried, they should at once be sown in 3- or 4-inch pots, one in each, in which they may be grown till late autumn or early spring, when they should be transferred to a piece of specially prepared land in the middle of an ordinary wheat field. Here they should be planted at least one foot asunder each way, with a space a foot or two clear from the ordinary crop. By giving the plants so much room, each tillers to its full extent, while the grain when ripe runs little risk of being stolen by birds.

MESSRS GARTON'S WORK AS HYBRIDISERS.

Of all who have made attempts in the hybridisation of grain, no one else has attained anything like the success of the brothers Garton of Newton-le-Willows, Lancashire. Their business was flour-milling, and, of course, they had an interest in grain. As an amusement and hobby they made several attempts at crossing cereals between 1880 and 1883; but owing to the use of plants in which the organs of reproduction were too far advanced, their efforts were fruitless. After 1884 they used ears in a much earlier stage of development, and from that date forward their success may be traced. They very soon became expert hybridisers, and were not only successful with wheat,—as already said, perhaps the easiest of all the grains to fertilise,—but were soon almost equally successful with oats and barley.

At first Messrs Garton used only varieties common to the district or country, but by and-by they drew on the whole world for wild and cultivated varieties from which to get some special quality which they desired to engraft on the new varieties they were about to produce. In a few years they had an immense number of varieties, amounting to many thousands, each of which they grew in short rows of 10 yards. By 1893 they had about 10 acres devoted to small patches of new varieties, and in order to let the outside public know something of their work, they decided to exhibit samples of their new sorts of grain at that year's show of the Highland and Agricultural Society of Scotland at Edinburgh. The directors of the Society were much impressed with the Messrs Garton's exhibit, and the botanist to the Society, Professor M'Alpine, and Mr Speir, Newton, were delegated to inspect their trial-grounds just before harvest, and report on them.[1]

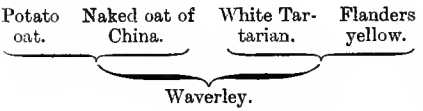
So slow is the work of the hybridiser that, although the Messrs Garton had been steadily at the work from 1884, they were unable to make any public display of their work till 1893, and it was not till 1898 that they were in a position to put any new varieties in the hands of the public. Early in 1898 they presented to the Highland and Agricultural Society one bushel each of three varieties of oats, which were handed to Mr Speir of Newton, to be tested and reported on. These were unnamed at the time, but were ultimately designated Tartar King, Waverley, and Pioneer. These and others were grown at Newton for two seasons, and reported on in the *Transactions* of the Society for 1900.

The most notable of the varieties of oats introduced by Messrs Garton has been *Abundance*, a cross between white August and white Swedish, which was first offered to the public in 1892. This is a white oat of good colour and milling

[1] *Trans. High. and Agric. Soc.*, 1894.

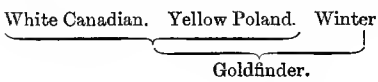
quality, which produces a large quantity of grain, and is now in general cultivation under various names all over the world.

Waverley is a longish white oat of heavy cropping quality. Its pedigree is as follows:—



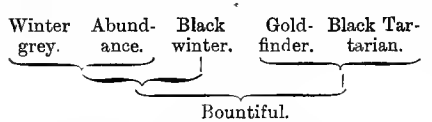
This oat is very popular in Scotland. It was introduced in 1898.

Another oat of a different type—viz., *Goldfinder*, a yellow oat—was introduced in 1899. This oat has the following pedigree:—



Goldfinder has exceptionally well-flavoured grain and straw, and few sorts yield a higher proportion of meal to grain. Yet, on account of its yellow colour, it has never become a very great favourite with either farmers or merchants. It is a very heavy cropper, and, because of its colour, the grain is generally consumed on the farm. This oat is rather slow in ripening, but being a hardier oat than most varieties, it can be sown very early in the season where the circumstances permit, and where this is done it ripens about the ordinary period.

Bountiful is one of the most noted black oats which the Messrs Garton have introduced. It has the following pedigree:—



Bountiful is thus descended from other varieties of exceptional merit, which have been in cultivation for only a few years. Being from such well-known heavy croppers as Abundance and Goldfinder, it is not to be wondered at that it is promising well. It is a black oat of exceptional dark colour.

An oat of quite a different kind, and suited for altogether different circumstances, is *Tartar King*. It was introduced in 1898, and has the following pedigree:—

Tartar King is a very early oat, with the grain all on one side of the ear. Its straw is of a remarkably stiff quality. It is specially adapted for lands which are in a high state of cultivation, or where the crop is inclined to lodge. The grain is coarse and husky, while the straw, like most other varieties having much of the Tartarian strain in them, is not very well suited for fodder purposes.

The Messrs Garton have also introduced several new varieties of barley, of which the following have given the best results: *Standwell*, *Maltster*, *Ideal*, and *Eclipse*. Each of these varieties has some good quality peculiar to itself. Eclipse is a six-rowed barley of the Chevalier type, which gives a very heavy yield of grain of good quality.

Messrs Garton also introduced several new varieties of wheat, but these do not seem to have met with the same success as their oats.

They have recently put on the market a perennial Italian rye-grass, which is a cross between perennial and Italian rye-grass. It seems as if it would be a useful addition to our grasses, but as yet has been too short a time in cultivation to be spoken of with great confidence. A perennial red clover has also been recently introduced by the firm. It is a cross between the ordinary red and wild red clover. Hitherto it has done well, but as yet has not had a very extended trial.

Progress of Hybridisation.

The possibilities of the cross-fertilisation of cereals have, since the work of the Messrs Garton was made known, been appreciated in a way they seem never to have been before. Not only are there now eminent scientists all over the world devoting attention to the subject, but there are also Government departments of various countries which have specialists set apart for this particular work. There are likewise various

public companies which lay themselves out for the propagation and sale of new varieties.

It therefore seems probable that in the near future considerably more progress may be made in this department than has hitherto been the case. That this work is much needed is admitted by every one. The standard varieties of grain in every country are difficult to supersede, yet it is the case that their number is being gradually reduced.

MENDEL'S LAWS AND THE IMPROVEMENT OF GRAIN.

The discovery of the operation of what are known as Mendel's laws of heredity has supplied a wonderful stimulus to those engaged in the production of new and improved varieties both of plants and animals. In a paper on "Heredity in Plants and Animals" in the *Transactions of the Highland and Agricultural Society of Scotland*,[1] by Professor Wood and Mr R. C. Punnett of Cambridge University, there is given an interesting *résumé* of experimental work with plants and animals, showing the operation of Mendel's principles. In reference to Mendel and his work the writers say: "Thanks to Mendel's remarkable discovery, we are at last beginning to recognise the true meaning of heredity, and to realise the great powers of control over living things with which this knowledge endows us. We begin to understand many of the mysterious things that happen when crosses are made among animals and plants—why a character often skips a generation, why the type is often broken to give rise to new forms, and what is the meaning of reversion. The foundations of this knowledge were securely laid by Gregor Mendel, an Austrian monk, in the garden of the monastery of which he afterwards became the head. Mendel has been dead for nearly thirty years, and it was as long ago as 1865 that his discovery was first given to the world. But his ideas were in advance of his time; they excited little interest and were soon forgotten. It was not until 1900 that his paper on the pea was unearthed, and scientific men began to realise what a far-reaching discovery this was that Mendel had made so many years ago. As a young man he had studied the natural sciences in Vienna, and had become interested in the problems of heredity. On returning to his monastery he devoted much of his leisure to carefully investigating the manner in which characters are transmitted in the common pea. From the results of his experiments he deduced certain principles which he found to hold for all the various characters he studied. During the past few years these principles have been confirmed and extended, not only for many plants but for animals as well."

[1] Fifth ser., vol. xx., 1908, p. 36.

WHEAT BREEDING ON MENDEL'S PRINCIPLES.

Experimenters have already attained encouraging success in the application of Mendel's laws to the raising of improved varieties of grain. A prominent investigator in this direction is Mr R. H. Biffen, Botanist to the Department of Agriculture in the University of Cambridge. In regard to work carried out by him we take the following from the paper above referred to:—

"On the rediscovery of Mendel's laws in 1900, Mr Biffen began to work out the inheritance of various characters in wheat and other farm crops. Some of his results are shown in fig. 415 A, the following description of which will best explain the method.

Inheritance of Beard and length of Ear.

"Two varieties, P, P, were crossed which differed only in two characters—viz., beard and length of ear. The first cross, F_1, is beardless, and we express this in Mendelian terms by saying that the beardless condition is dominant, the bearded condition recessive. The inheritance of length of ear shows neither dominance nor recessiveness, for in the first cross, F_1, the length of the ear is intermediate between that of the parents. The characters of the first cross are exactly the same, whichever way the cross is made, and all the individuals of which it is composed are practically identical.

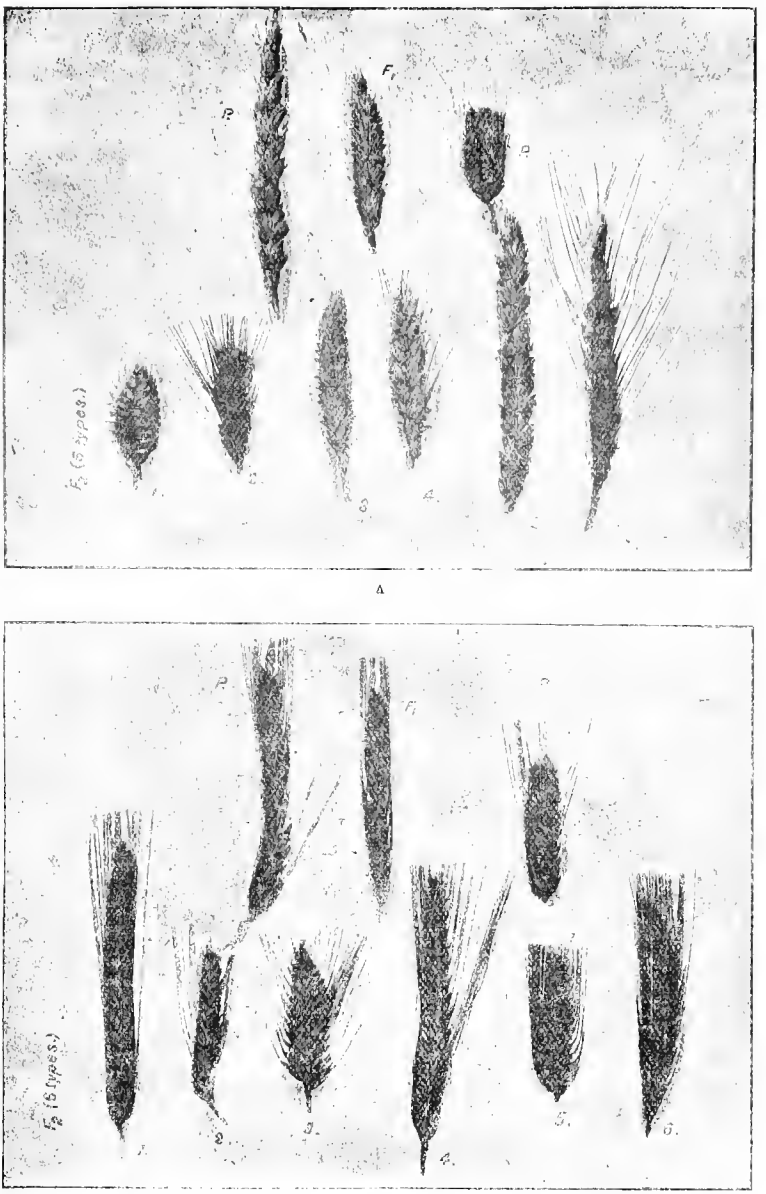


Fig. 415.—A. *To illustrate the results of crossing two wheats differing in two pairs of characters.*
B. *To illustrate the results of crossing two barleys differing in two pairs of characters.*

Natural cross-fertilisation is so rare among the cereals that the first cross may be left to itself to produce seed by self-fertilisation. The seed so produced is sown, and the second generation, F_2, is found to be no longer uniform. In 1899 we should have said that the type had been broken, and that new variations had

arisen without law or order. Now, in the light of Mendel's conception of unit characters, we realise that this is merely a rearrangement of existing characters in new combinations.

"These points are well illustrated by the six types shown in the figure.

"Type 1 has inherited the dense ear from one parent, the beardless condition from the other.

"Type 2 combines both the characters of the dense-eared bearded parent.

"Type 5 combines both the characters of the long-eared beardless parent.

"Type 6 has inherited the long ear of one parent, the beard of the other.

"In Types 3 and 4 the intermediate length of ear of the first cross is reproduced with and without the beard.

"If a numerous second generation is grown, and the plants showing the above six types sorted out and counted, it is found on the average that out of every sixteen plants there are three of Type 1, one of Type 2, six of Type 3, two of Type 4, three of Type 5, and one of Type 6.

New Types.

"It is at once evident that in the second generation there are two new types, Nos. 1 and 6, whose novelty consists in a recombination of characters existing in one or other parent. Thus the beard of the short-eared parent has been removed from No. 1 and transferred to No. 6, which thus starts a new bearded long-eared type. But No. 1 has thus been left with the short-eared character deprived of beard, and this combination is also new.

How to pick out fixed Types.

"Now in making a new variety we want not only to get a few specimens showing the desired characters, but to isolate a fixed type and grow enough to distribute for seed. Here, too, Mendel's work helps us. Mendel defined as recessive those characters which disappear in the first cross. In the case under consideration the beard is a recessive character, and from the definition a bearded individual of the second generation cannot contain the beardless character. For this is dominant over beard, and the individual would be beardless. In other words, an individual of the second generation showing a beard or other recessive character must be pure as regards that character. We know, therefore, that seed of Types 2, 4, and 6 must, if grown, produce a pure bearded progeny.

"Again, an individual carrying both the long- and short-eared characters has, as in the first cross, ears of intermediate length. This intermediate length is, so to speak, the mark of the mongrel, and the seed of individuals having it will produce long, short, and intermediate ears as shown by the second generation. Types 3 and 4, therefore, will not breed true, and are useless. A long-eared type and a short-eared type must be pure, and will breed true. Types 2 and 6 are therefore pure as regards both characters, and can be at once taken as fixed.

"We are now left with Types 1 and 5. These must be pure as regards length of ear, but they contain the dominant beardless character, which may be masking the recessive bearded character. In order to pick out the pure beardless, we must resort once more to the breeding test. Seed must be collected from a number of plants separately and sown in separate plots. We shall then find that, on the average, one plant out of every three will breed true to the beardless condition. Further, Mendel indicates, and experience confirms, that if a plant begins to breed true it will continue to do so.

Inheritance of other Characters.

"We have now seen how to obtain new combinations by crossing two varieties of wheat differing in only two characters, and how to pick out those individuals of the new types which will breed true. Mr Biffen has worked out the inheritance, not only of the two characters quoted above, but of all the obvious characters of wheats, such as colour of grain and chaff, presence or absence of hairs, shape of glumes, and so on. Particulars are given in his papers in the *Journal of Agricultural Science*. He has also succeeded in working out the inheritance of the far more practically important characters of strength and disease-resistance, and his results in this direction are of such great interest that they must be given in some detail.

Definition of Strength.

"Strength is the term used by millers and bakers to sum up a number of properties which together make a flour valuable for baking. A wheat is said to be a strong wheat when it produces a flour which will make, when baked, large shapely loaves. The strongest wheats on the English market come from Canada and Russia. We may give a numerical value to strength by marking the very best samples of these foreign wheats at 100. On this scale ordinary samples of these wheats must be marked at 90-95, and good average samples of home-grown wheat at 60-65. The difference in market-price between a wheat marked at 95 and a wheat marked at 65 is about 5s. a quarter.

A Strong Parent.

"The best Canadian wheat, graded as No. 1 Hard Manitoba, is composed of at least 60 per cent of one variety known as Red Fife. This variety has been grown in England under its own name for seven years, and as Cook's Wonder for fifteen years, without the least sign of losing its strength, and we are therefore fairly justified in assuming that it breeds true to strength under English conditions. But it is not a suitable wheat for the British farmer, as it seldom yields a crop of more than about three quarters per acre. Now our common home-grown varieties are, as a rule, excellent croppers, but very deficient in strength.

Inheritance of Strength.

"We have, therefore, two kinds of wheat—Red Fife, which is strong but a bad cropper, and any of our home-grown sorts, which are weak but good croppers. If now strength and cropping power are characters which can be inherited according to Mendel's laws, like beard and length of ear, then all we have to do is make a cross between these two sorts, and we shall be able to pick out from the second generation fixed forms in which a recombination of strength from the Canadian parent and cropping power from the English parent have taken place. We shall thus obtain a new type of wheat which crops as well as any of our ordinary varieties, and yields grain which, in virtue of its strength, is worth say 5s. per quarter above the market-price of present-day home-grown wheat.

New Types.

"Mr Biffen has tried the experiment outlined above, and proved that strength is a dominant character. He has picked out from the second generation a number of fixed types, the best of which have been grown for two years in field-plots, of which some in 1907 were an acre in extent. The soundness of Mendel's method of picking out the fixed types is shown by the fact that, even among the enormous number of plants growing on an acre plot, there was no sign of reversion to parent forms or any other departure from the type which had been picked out. Both in 1906 and 1907 grain from some of these new fixed types was sent to be tested in the mill and in the bakehouse. In 1906 they were marked at 84 to 88, in 1907 at 88 to 90. Remembering that ordinary Fife is 90 to 95 and ordinary English only 65, it is clear that these new types have to all intents and purposes inherited the strength of their Canadian parent and are breeding true. Up to the present the object has been to increase the stock of seed as rapidly as possible, and very thin sowing of under 1 bushel per acre has been practised. It is impossible to say, therefore, how well they will ultimately crop, but even with this excessively thin sowing a yield of 42 bushels per acre was produced this year by two of the new varieties. Adjacent plots of Square Head's Master and Browick, similarly sown and manured, yielded only 39 bushels per acre.

"With the seed of the best of these new types something like ten acres have been sown this autumn on the Cambridge University farm,—an area large enough to give a reliable verdict as to their cropping power, and if the verdict is favourable, to grow seed enough for extended tests throughout the country.

Damage due to Rust.

"A short time ago some striking figures were published showing the money value of the damage done annually to cereal crops by such fungoid diseases as rust.

According to the International Bureau of Plant Pathology, the loss of crop value in Germany alone amounted in 1891 to £20,000,000, or about one-third of the total value of the crop. It is estimated that the annual loss throughout the world is not less than £100,000,000. These diseases are so widely spread throughout the country that remedial or preventive measures are practically out of the question. The only hope of reducing the damage they cause is to produce immune varieties of crops.

A Rust-proof Parent.

"During the last seven years Mr Biffen has had under observation on the University farm plots of almost every known variety of wheat. These plots are crowded together in a cage of wire-netting to keep off birds, and it has been noticed every year that, whilst most of the varieties have suffered greatly from rust, one of them has almost kept entirely free. It is safe to assume, therefore, that this variety is immune to rust, or, in other words, rust-proof. This variety is a small-eared bearded variety without a single good character except its immunity to disease. It occurred to Mr Biffen that this immunity might be a character which could be inherited in accordance with Mendel's laws, in which case it could be transferred to any other variety just as the beard in the case already described.

Inheritance of Immunity.

"Another variety had been noted every year for its excessive susceptibility to rust, which was so great that in bad rust years it was unable to set seed. This susceptible variety was bearded like the immune one, but, when not destroyed by rust, formed long ears. These two varieties were crossed together, and the first cross came with ears of intermediate length, and was so susceptible to rust that it set seed with difficulty. However, enough seed was obtained to grow a fairly numerous second generation, when it was found that, on the average, one plant in four of this generation was rust-proof. This experiment has been repeated several times, and several thousand second-generation plants have in all been counted. The evidence is quite conclusive that immunity to rust is a recessive character. This being established, the transference of immunity from the original short-eared bearded variety, in which it was found, to the new types, in which strength and cropping power have been already combined, is merely a matter of routine, requiring one year to grow the first cross, a second year to grow the second generation, from which the first recessive rust-proof forms can be picked out at once, and finally two or three years to increase the stock. We shall then be possessed of wheats which will bake as well as the best Canadian, and, since they will be free from disease, crop better than any varieties at present on the market.

Possibilities of further Work.

"This demonstration of the possibility of transferring immunity to disease from one variety to another is an achievement of the greatest scientific and practical importance. It seems to offer the most hopeful method of checking disease yet suggested. If immune strains of any species of plant or animal can be found, no matter how useless they may be from other points of view, there seems to be no reason why their immunity should not be transferred by crossing to our present valuable varieties which are being ravaged by disease. In this way it may be found possible to produce high-class horses and cattle immune to the diseases which are the scourge of the South African farmers, sheep which will be proof against anthrax, black quarter, and other diseases that attack sheep at home, and pigs immune to swine fever."

SOWING CEREALS.

SEED-TIME.

For practically all his crops, excepting wheat, the farmer has his seed-time in the cheery months of spring. On all tillage farms the spring is a time of great stir and bustle. The prognostics and variations of the weather are watched with the keenest interest and anxiety, for not only the progress of the spring work but also the returns of the harvest are greatly influenced by the character of the weather during the seed-time.

Seasonable Working of Land.—Field-work will now be pushed on with all possible speed. Yet there are more points to be considered than the mere progress of the work. In particular, care must be exercised as to the condition in which the different kinds of soils are tilled and prepared for the crops. To stir stiff clay when it is soaked with wet would be ruinous. Better delay a little than commit the seed to a cold, unkindly, ill-prepared seed-bed. Better let the men and horses stand idle for a few days than run the risk of destroying the year's produce by working the land in an unseasonable condition. On the other hand, when the weather is favourable, and the land in good condition for tillage operations, let all hands do their very best, so that full advantage may be taken of every favourable spell of weather.

Selecting Seeds.

Farmers cannot be too careful in the selection of seeds. It matters not what the crop may be, the best possible seed should be secured. To ensure thoroughly reliable seeds of a high character, an extra outlay of a few shillings per acre may be entailed, but then these *few shillings* may add pounds to the value of the crop.

Improvement in Seeds.—In this matter of seeds, the farmers of the present day are well situated compared with their brethren in former times. The development of the Seed industry is indeed one of the most notable—one of the most beneficial—features in the progress of modern agriculture. The improvement of the animals of the farm has been accomplished on the farms by the stock-owners themselves. Equally important and equally great in its way has been the improvement of the plants of the farm. And this latter work has been carried out in the most thorough and energetic manner by a number of extensive and influential seed firms, who have for many years devoted great attention not only to the improvement of the old varieties of the farm crops, but also to the propagation and development of new varieties of increased producing power. There are many eminent firms who have in this way rendered good services to the country. Amongst the names most prominently associated with this great work of plant improvement are those of Sutton, Carter, Webb, Drummond, Dickson, Garton, and Hunter; but there are several other firms which have also been active in similar well-doing.

The part which these enterprising firms, who give us the improved, selected, and tested seeds, have played in the progress of modern agriculture, has been greater by far than is generally recognised. It has, of course, been a matter of business, not of philanthropy, with them; all the same, it is right to acknowledge the great power which the development of the seed trade has exercised in the advancement of agriculture.

Buy Seeds in Good Time.—Sowing is sometimes delayed by dilatoriness on the part of the farmer in providing the necessary supplies of seeds. Have these on the farm *before* they are required, so that they may be at hand when a suitable time arrives for sowing.

Change of Seed.—It is well known amongst practical farmers that great advantage may be derived by judicious change of seed. As a rule with roots, fresh seed is introduced every year, for it is only in exceptional cases where the farmer grows his own turnip-seed, although this latter practice is with advantage being pursued to an increasing extent. With grain, however,

the rule is reversed. The home-grown seed is used for the most part; but it has been clearly shown that by an occasional change from one climate, one soil, and one system of farming to another, the vitality and producing power of a particular kind or "stock" of grain are substantially increased. When one considers the artificial influences by which our improved varieties of grain have been brought to their highly developed condition, one cannot be in the least surprised that such changes of scene and surroundings should often exercise a beneficial effect upon the crop.

But all changes are not successful. Neither are the conditions essential to success very fully known. In almost every change of seed, as in every change of a sire, there is something of the nature of an experiment. As a rule, a change of cereal seed from an early to a late district is followed by much benefit, notably in the earlier ripening of the crop, but also to some extent in the quantity and quality of the produce. The influence on the date of the harvest is most marked. For instance, by the habitual introduction of seed-oats from the south of Scotland every second or third year, the ripening of the crop on certain farms in the later districts of the north-east has been hastened by from six to ten days; and practical farmers acquainted with a late climate know that acceleration to that extent in harvest is a very important advantage—perhaps all the difference between a crop secured and a crop partially lost. The weight of the grain will also most likely be increased 2, 3, or more pounds per bushel. Then in taking seed from a late to an early district there may sometimes be an advantage—notably an increase in the bulk of the produce, though there are many exceptions to this experience.

A good plan in changing seed is to try the change on a small scale in the first year, and if the results are satisfactory, use the variety more extensively in subsequent years. Farmers should be experimenting in this way very frequently, for by introducing fresh varieties well suited to their land, the produce of their crops may be substantially increased. A change of seed from a clayey to a light loamy or sandy soil is generally beneficial.

New Varieties of Farm Plants.—Farmers also derive much benefit by taking advantage of the many new and improved varieties of grain and roots which are brought out by experimenting seedsmen. As already shown, our leading seedsmen are continually engaged in propagating fresh and improved varieties of farm crops, more particularly of grain, mangels, swedes, turnips, and potatoes, and by availing themselves of these new and vigorous sorts of proved excellence, farmers may to a marked extent enhance their produce.

At the same time, it is well to say that caution should be exercised in introducing new varieties. Let them be tried on a small scale at the outset, and adopted extensively only after their suitability and high qualities have been unmistakably established.

Testing Seed.—Farmers should carefully avoid using *weak* or *unreliable* seed. Seeds of all kinds may now be procured pure, and of certain germination. This should always be insisted upon, and farmers should themselves test the seeds when they take them home. Even home-grown seed, however well it may look, should never be sown without having been first carefully tested. This may be done very easily with grain or grass seeds, by placing say a hundred seeds between two folds of damp blotting-paper laid on a meat or soup plate, with another similar plate placed face downwards over that plate. No artificial heat need be used, and the plates may sit on an open shelf in the farmer's parlour. The blotting-paper should be damped every day by sprinkling a little water on it by the hand. The object of having the two plates placed face to face is to cause a current of air to pass over the seeds. In this way cereal seeds will germinate in about a week, and grass-seeds in about three weeks. An efficient testing apparatus may be purchased at a moderate cost.

Some consider it more reliable to test the germination of cereals in pots filled with soil.

Grain-seeds are often tested under a very thin damp turf in a well-exposed spot in the farmer's garden. We have

also seen it done on damp turfs, placed on the rafters over the heads of cattle, where, of course, the temperature is considerably higher than outside early in spring, when testing is usually carried out.

Clover, *turnip*, or any other leguminous seeds may be tested in a more simple and expeditious manner. Count out say 100 seeds, roll them into a piece of flannel, and dip into boiling water for four or five minutes, and on opening the piece of flannel all the reliable seeds will be found much swollen, and actually germinated, with the elementary root shooting out. The seeds which do not present this swollen appearance cannot safely be reckoned upon, and the quantity of seed to be given per acre should be regulated by the percentage of the reliable germinating seeds.

SOWING WHEAT IN AUTUMN.

The autumn is the season in which the main portion of the wheat crop is sown. Indeed, comparatively little spring wheat is now grown in this country. Spring wheat is a more risky crop, and rarely yields so well as the autumn-sown; in fact, the earlier the sowing, and the longer the period of growth that wheat can be given, the better the crop, as a rule. A five-month crop is preferable to a nine-month one, in mere economy of time, of course, but only if the ground is under crop all the time: if the land is lying bare all winter it is losing nitrates which the autumn-sown crop appropriates to good purpose. And where wheat is to be the next crop, the rotation should be arranged to have the ground clear of its predecessor in September or October at latest, so that winter wheat may be sown. Where corn is to follow a root crop, and the latter cannot be cleared off the ground until spring, it is then better to sow barley or oats as the spring corn crop.

Land intended for autumn or winter wheat is ploughed as early in autumn as possible. Indeed the plough is often at work for the next crop before the harvesting of the preceding crop is quite finished.

Fallow Wheat.—Bare fallow, as we have seen, has now almost disappeared, but any portion of land which has been fallowed during the summer is the first to be prepared for wheat. It has perhaps received a dressing of dung, which may have been drilled in. If so, the first operation is levelling the drills which cover the dung by harrowing them across with one double turn of the harrows. After the land has been harrowed down, any root-weeds brought to the surface should be removed, but the surface-weeds will soon wither.

Ploughing for Wheat.—The land is then feered, to be gathered up into ridges; and if thoroughly drained, or naturally dry, one gathering-up makes a good seed-bed; but wet land, to lie in a good state all winter, should be twice gathered up. The second gathering-up should not be immediately after the first, for a short interval should elapse to allow the land to subside, which rain will accelerate.

Should the fallow have had the dung spread upon the surface and ploughed in with feered ridges in gathering up, the feering left half-ridge at the sides of the field, now that the land is gathered up for the seed-furrow, is converted into one whole ridge.

Grubbing for Wheat.—But a practice came into use, with the introduction of the grubber, that possesses advantages on strong land in a dry state, which is, to put the seed-wheat into the ground with the grubber, upon gathered-up ridges that covered in the dung of the fallow, and to finish the work with one double-tine harrowing along the ridges. When the grubber is so used, the land is gathered up in finished ridges in the fallow, as grubbing cannot alter the form of ridges.

Advantages of Grubbing.—When a tough waxy clod arises on ploughing strong land, rather wet below, for a seed-furrow, or when unsettled weather threatens, the grubber will keep the dry ameliorated soil upon the surface, and accelerate the seed-time considerably.

New or Old Seed.—The land being thus prepared for the seed, it is quite possible for a part of the new crop to be thrashed out for seed in time for sowing in autumn; but those who sow early cannot procure new seed, and must use the old. But although the new crop

were secured in good time to afford seed for sowing in autumn, it is better to sow old wheat than new. New wheat germinates quicker than old, but is more easily affected by bad weather and insects; and consequently its braird is neither so thick nor so strong as from old wheat — that is, from seed of the preceding year; for very old wheat may have been weakened in vitality even in the stack, or been much injured by the weevil in the granary.

Time for Sowing.—Some farmers sow wheat on fallow early in September; and where there is much fallow and strong land this is a proper season to begin. The objection is, that should late autumn and early winter prove mild, the plant will become too rank before cold weather sets in to check its growth. October is considered by many the best period for sowing winter wheat, as the risk of rank growth is avoided.

Quantity of Seed for Wheat.—The quantity of seed used for wheat varies from 1¼ to 3 bushels per acre. The smallest quantity is used for early autumn sowing, especially on good rich land, and the largest for sowing in spring. The questions of thick and thin sowing and different methods of sowing are discussed in the section on "The Germination of Seeds" in this volume.

Variety to Sow.—The varieties of white wheat well suited to be sown in autumn are now so numerous that it is impossible here to indicate which is the best for a particular locality. Upon inferior soils it is safest to sow a red wheat, which, although realising a lower price in the market, will yield a larger increase. In this matter the farmers in the different localities must exercise their own judgment, giving due consideration to the opinions of farmers in the neighbourhood as to the varieties best suited to the locality.

Methods of sowing are dealt with in connection with spring sowing.

Water-courses. — The finishing processes of harrowing and of water-furrowing are the same as in spring; but as water is more likely to stand upon the land in winter, gaw-cuts must be made with the spade in every hollow on the surface and across head-ridges, even on thoroughly drained land, to quickly carry off large falls of rain.

Harrowing.—As regards the harrowing, it is right to leave on wheat-land in winter a round clod upon the surface. Such clods afford shelter to the young plants from wind and frost, and, when gradually mouldered by frost, also increase the depth of the loose soil.

Frost throwing out Plants.—Wherever land is harrowed to a fine tilth in autumn, rain batters its surface into a crust, and frost heaves it up in spring like fermented dough, by which the plants are raised up with the soil, and, when the earth subsides in a thaw, left upon the surface almost drawn out by the roots. Thorough-draining is the only safeguard against rain and frost acting in this manner upon a fine surface in winter.

When land is naturally strong enough to grow wheat, and yet is somewhat soft and wet below, to make it probable that the plant will be thrown out, *ribbing* with the small plough will give a deeper hold to the plant than common ploughing. The wheat is sown broadcast over the ribs, and harrowed in with one double tine along them. Ribbing is not suitable on fresh-ploughed land, as even the small plough would go too deep, and make the drills too wide; nor is it advisable on land that has not been ridged up.

Another mode of preventing the throwing out of wheat on soft land, is first to feer the land into ridges, sow the seed broadcast between the feerings, plough the seed in with a light furrow with the common plough, and leave the surface unharrowed and rough all winter.

Deep sowing — from 1¼ to 1¾ inch deep—is regarded by many as the surest preventive. The sowing of the seed by the drill sower, which is now largely practised, greatly lessens the risk of loss by the plants being thrown out.

Rolling.—Rolling wheat in autumn is rarely practised, except to consolidate soft land. In reference to this point, a writer says: "We have for the last three seasons rolled nearly the whole of the autumn-sown wheat when a favourable opportunity could be obtained, making the surface perfectly smooth and fine. The old idea of rough lumps lying here

and there being of advantage for shelter is neither more nor less than an antiquated fallacy. After wheat is sown, the land cannot be made too firm. It is good for all land where a roller can be used without what is called *poaching* the soil. We have tried repeated experiments, and the rolled portions were always the best. It is true the wheat is rolled in spring whenever the season will permit; but these clods are pressed down and for a time retard this, and check the tillering power of the plant. The autumn-rolled wheat requires only to be harrowed or hoed in spring. These observations are made from a three years' trial of the system." A firm seed-bed is unquestionably, as we have already pointed out, beneficial to wheat. But so are surface clods in winter and spring. The clods lying on or in the surface cannot possibly prevent fresh rootlets pushing their way into the soil around them.

Wheat after Beans.—The bean-land is the next sown with wheat in autumn; and the land occupied by summer tares, or other summer forage crop, if in the same field with the beans, is sown with wheat at the same time. The land is feered and gathered up and sown when the soil has been allowed to subside for a few days.

Where bean-land is strong and the ridges sufficiently round, a four-horse grubber may be used to make the seed-furrow instead of the plough. The grubber succeeds in this case very well as far as the wheat is concerned, and it has the advantage in a late autumn of getting through the work expeditiously, and keeping the aerated soil upon the surface. But on strong soil, not thoroughdrained, and in a comparatively flat state, grubbing is not the best preparation for wheat after beans, because the seed is apt to rot and the soil become sour.

Grubbed soil may require only one double turn of the harrows along the ridges.

Wheat after Potatoes.—The potato-land, having been harrowed after the potatoes have been raised, is feered and gathered up, and sown with wheat. It is better to let the soil subside a little, although the usual practice is to sow the wheat as soon as it is ploughed, the season getting late by the end of October. In many cases wheat after potatoes is sown broadcast on the unploughed surface, the seed in this case being either ploughed in with a light furrow less than two inches deep or covered with a cultivator. The same process is sometimes followed on strong land where the root crop has been consumed on the land by sheep.

Wheat after Grass.—To a large extent wheat follows grass and clover in the rotation. Indeed in Yorkshire and other parts of England wheat is now more largely grown after one year's hay than after any other crop, the seed being sown in the autumn. The skim-coulter plough is used to bury the sod, the Cambridge roller is then put on, the land is harrowed lightly so as not to bring turf to the surface, and the seed is sown with the seed drill.

SOWING WHEAT IN SPRING.

As already stated, only a small extent of the wheat crop is sown in spring, the main portion being sown in autumn.

Land for Spring Wheat.—To ensure a good crop of spring wheat, the land should be for some time in good heart, otherwise the attempt will inevitably end in disappointment. Wheat cannot be sown in spring in every weather and upon every soil. Unless the soil has a certain degree of firmness from clay, it is not well adapted for the growth of wheat —it is more profitable to sow barley upon it; and unless the weather is dry, to allow strong soil to be ploughed in early spring, it is also more profitable to defer wheat, and sow barley in the proper season. The climate of a place affects the sowing of wheat in spring; and it seems a curious problem in climate why wheat sown in autumn should ripen satisfactorily at a place where spring wheat will not. Experience makes the northern farmers chary of sowing wheat in spring, unless the soil is in excellent condition, and the weather very favourable for the purpose.

Date of Spring Sowing.—In former times, even under the most favourable circumstances, wheat was seldom sown after the first week of March, but later varieties have been introduced which may be sown as late as April.

On farms possessing the advantages of favourable soil and climate, and on which it is customary to sow spring wheat every year, the root-land is usually ploughed with that view up to the beginning of March; and even where spring wheat is sown only when a favourable field comes in the course of rotation, or the weather proves tempting, the land should still be so ploughed that advantage may be taken to sow wheat. Should the weather take an unfavourable turn after the ploughing, the soil can afterwards be easily worked for barley.

Tillage for Spring Wheat.—The land should receive only one furrow—the seed-furrow—for spring wheat, because if ploughed oftener, it would be deprived of that firmness so essential to the growth of wheat.

It is probable that a whole field may not be obtained at once to be ploughed, and this often happens for spring wheat; but when it is determined to sow wheat, a few ridges should be ploughed as convenience offers, and then a number of acres may be sown at one time. In this way a large field may be sown by degrees, whereas to wait till a whole field can be sown at once, may prevent the sowing of spring wheat that season. Bad weather may set in, prevent sowing, and consolidate the land too much after it had been ploughed; still, a favourable week may come, and, even at the latter end of the season, the consolidated land can be ribbed with the small plough, which will move as much of the soil sufficiently as to bury the seed.

Double-furrow Plough.—To expedite the ploughing of the seed-furrow at a favourable moment, the double-furrow plough is used by some, though not so largely now as a few years ago. A double-furrow plough, made by Ransome, Sims, & Jefferies, is shown in fig. 416.

Advantages of the Double-furrow Plough.—The double-furrow plough is usually worked with 3 horses, and as to the question whether it effects a saving of draught as compared with two single furrow-ploughs, there has been much discussion. Experiments with the dynamometer have shown that there is little saving in this respect, and that the 3 horses have to exert about as much force as 4 horses, with 2 common ploughs doing the same amount of work, with a slight difference in favour of the double-furrow plough. In a trial with the double-furrow plough and others, the common plough, with a furrow of from 6½ to 7½ inches deep, gave a draught from 4 to 5 cwt.; while 9 double-furrow ploughs, with an average depth of furrow of 5½ inches, gave an average draught of 7 cwt.

Latterly double-furrow ploughs have to some extent been losing favour in certain parts of the country where they obtained a footing. The modern Anglo-American plough is preferred by many for speedy

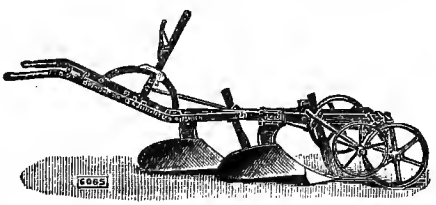


Fig. 416.—*Double-furrow plough.*

ploughing. Still, in some circumstances, the double-furrow plough may be employed with advantage.

Several improvements have lately been effected in the double-furrow ploughs, and now they are, as a rule, lighter in draught, and more easily manipulated, than in former times.

Sowing Operations.

Placing Sacks in the Field.—There is some art in setting down sacks of seed-corn on the field. The plan of placing the sacks of course depends on whether the seed is to be sown by the hand or by a machine. The sacks are set down across the field from the side at which the sowing commences. One row of sacks is sufficient, when the ridges are just long enough for the sower to carry as much seed as will bring him back again to the sack, and the sacks are then set in the centre of the ridge. When the ridges are short, the sacks are set upon a head-ridge; and when of such length as the sower cannot return to the sack by a considerable distance, two rows of sacks are set, dividing the length of the ridges equally between them, setting the two sacks on the same ridge. The sacks are placed upon the furrow-brow of the

ridge, that the hollow of the open furrow may give advantage to the carrier of the seed to take it out easily as the sack becomes empty. In thus setting down the sacks of seed, it is intended to give the supply of seed more easily to the man who sows the seed by hand.

When a machine is employed to sow the seed, the sacks are set upon one of the head-ridges connected with the gate of the field, unless the field is so long that a row of sacks must be placed in the middle.

Where to begin Sowing.—If the surface is level, it matters not which side of the field is chosen for commencing the sowing; but if inclined, the side which lies to the left on looking down the incline should be the starting-point. The reason for this preference is, that the first stroke of the harrows along the ridge is most difficult for the horses to draw; and it is easiest for them to give the first stroke *downhill*. This first action of the harrows is called *breaking-in* the land. It is the same to the sower at which side he commences the sowing, but ease of work for the horses ought to be studied.

Seed Carrier.—In Scotland the carrier of the seed is usually a woman, and the instant the first sack of seed is set down, she unties and rolls down its mouth, and fills the *rusky*, basket, pail, or whatever she uses in conveying the seed, and carries it to the sower, who awaits her on the head-ridge from which he makes his start. Her endeavour should be to supply him with such a quantity of seed at a time as will bring him in a line with the sack where he gets a fresh supply; and as the sacks are placed half-way down the ridges when only one row is set down, this is easily managed; but with two rows of sacks, she must go from row to row and supply the sower, it being her special duty to attend to his wants, and not to consider her own convenience. Nothing can be more annoying to a sower than to have his sheet or sowing-basket served too full at one time and too stinted at another; as also to lose time in waiting the arrival of the seed-carrier, whereas she should be awaiting his arrival. When two rows are at a considerable distance, on long ridges, two carriers are required to serve one sower. Better that the carriers have less to do than that the sower lose time and delay the harrows, which will likely occur when the carriers are overtaxed.

Seed-basket.—The basket or vessel in which the carrier conveys the seed is of various patterns—a deep or shallow basket, or ordinary pail, sometimes carried on the head, and in other cases in the hand or on the arm and haunches. The seed is most easily poured into the sowing-basket from the seed-basket on the head. It should be filled each time with just the quantity of seed the sower requires at a time.

The Seed-sacks.—The mouth of the sack should be kept rolled down, that the seed may be quickly taken out, for little time is usually at the disposal of the carrier. The carrier should be very careful not to spill any seed upon the ground on taking it out of the sack, otherwise a thick tuft of corn will unprofitably grow upon the spot. As one sack becomes empty, the carrier should take it to the nearest sack; and as the sacks accumulate, they should be put into one, and carried forward out of the way of the harrows. It is a careless habit which permits the sacks to lie upon the ground where they are emptied, to be flung aside as the harrows come to them.

One-hand Sowing.—In former times the sower by hand in Scotland was habited in a peculiar manner. He sowed by one hand only, and had a sowing-sheet wound round him, as shown in fig. 417. The most convenient sheet is of linen. It is made to have an opening large enough to admit the head and arm of the sower through it, and a portion of the sheet to rest upon his left shoulder. On distending the mouth of the doubled part with both hands, and receiving the seed into it, the loose part of the sheet is wound tight over the left hand, by which it is firmly held, while the load of corn is supported by the part of the sheet which crosses the breast and passes under the right arm behind the back to the left shoulder. A *basket* of wicker-work, such as fig. 418, was very common in England for sowing with one hand. It was suspended by a girth fastened to two loops on the rim of the basket, and passing round the back of

the neck; the left hand holding the basket steady by the wooden stud on the other side of the rim.

Two-hand Sowing.—But the system of sowing with both hands is now more

Fig. 417.—*Sowing-sheet and hand-sowing corn.*

general than one-hand sowing. It should indeed be the universal method wherever hand-sowing is pursued. It is the most expeditious; and many people consider that the sowing can be done more evenly with two hands than with one.

For two-hand sowing a simple form of sowing-sheet is a linen semi-spheroidal bag, attached to a hoop of wood or of iron rod, formed to fit the sower's body, buckled round it, and suspended in front in the manner just described. Both hands are thus at liberty to cast the seed, one handful after the other.

Art of Sowing.—The following detailed description of the art of sowing by one hand is also so far applicable to sowing by both hands. Taking as much seed as he can grasp in his right hand, the sower stretches his arm out and a little back with the clenched fingers looking forward, and the left foot making an advance of a moderate step. When the arm has attained its most backward position, the seed is begun to be cast, with a quick and forcible thrust of the hand forward. At the first instant of the forward motion the fore-finger and thumb are a little relaxed, by which some of the seeds drop upon the furrow-brow and in the open furrow; and while still further relaxing the fingers gradually, the back of the hand is turned upwards until the arm becomes stretched before the sower, by which time the fingers are all thrown open, with the back of the spread hand uppermost. The motion of the arm being always in full swing, the grain, as it leaves the hand, receives such an impetus as to be projected forward in the form of a figure corresponding to the sweep made by the hand. The forward motion of the hand is accompanied by a corresponding forward advance of the right foot, which is planted on the ground the moment the hand casts forward the bulk of the seed.

The action is well represented in fig. 417, except that some would consider the sower should give his hand a higher sweep, especially on a calm day. The curve which the seed describes on falling upon the ground is like the area of a portion of a very eccentric ellipse, one angle resting on the open furrow and the other stretching 2 or 3 feet beyond the crown of the ridge, the broadest part of the area being on the left hand of the sower.

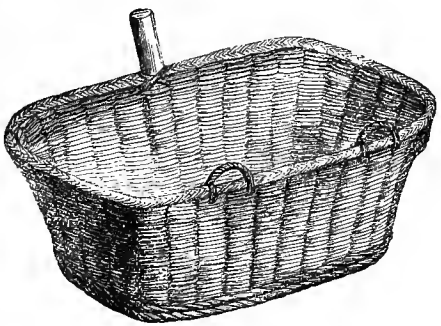


Fig. 418.—*English sowing-basket.*

The moment the seed leaves it the hand is brought back to the sowing-sheet to be replenished, while the left foot is advanced and the right hand is stretched back for a fresh cast, and thrown forward again with the advance of the right foot.

The seed ought to be cast *equally over the ground.* If the hand and one foot alternately do not move simultaneously, the ground will not be equally covered, and a strip left between the casts. When the braird—that is, the young plants—comes up, these strips show themselves. This error is most apt to be committed by a sower with a stiff elbow, who casts the grain too high above the ground. The arm should be thrown well back and stretched out, though, in continuing the action, with the turning up the back of the hand, the inside of the elbow-joint becomes pained.

If the hand is opened too soon, too much of the seed falls upon the furrow-brow, and the crown receives less than its proportion. This fault young sowers are very apt to commit, from the apprehension that they may retain the seed too long in the hand. If the hand is brought too high in front, the seed is apt to be caught by the wind and carried in a different direction from that intended.

When the wind becomes strong, the sower is obliged to walk on the adjoining ridge to the windward to sow the one he wishes; and the sower should cast low in windy weather.

Some sowers take long steps, and make long casts, causing some of the seed to reach across the ridge from furrow to furrow. Such a sower spills the seed behind the hand, and makes bad work in wind. The step should be short, the casts frequent, and the seed held firmly in the hand, then the whole work is under complete command. The sower should never bustle and try to hurry through his work; he should commence with such a steady pace as to maintain it during the day's work.

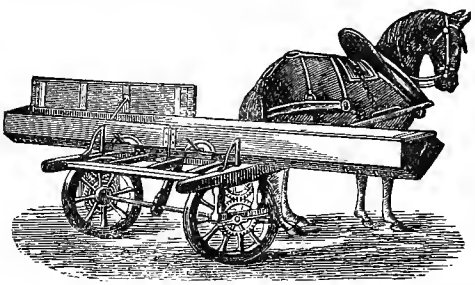


Fig. 419.—*Broadcast sower ready for work.*

A sower with *both hands* makes the casts alternate, the hand and foot of the same side moving simultaneously with regularity and grace.

Sowing-machines. — Hand-sowing has been to a large extent superseded by sowing-machines. These do the work better than it can possibly be done by hand, and their use is therefore to be commended. Of seed-sowing machines there are many patterns, some dropping the seed in drills, others scattering it broadcast. A material difference exists between these two classes of machines. The broadcast machine deposits the seed upon the surface of the ground, and is in fact a direct substitute for hand-sowing; and as it deposits the seed very regularly, this machine it now extensively used.

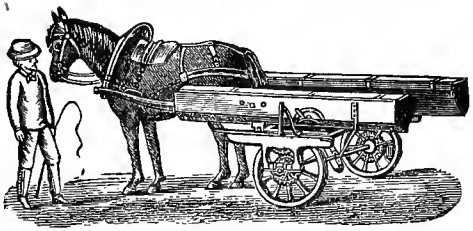


Fig. 420.—*Broadcast sower in transit.*

The *drill-machine* deposits the seed at once at a specific depth under ground in rows, and at such distances between the rows, and with such thickness in the rows, as the will of the farmer may decide.

The seed being left by the broadcast machine on the ground like hand-sowing, is buried in the soil more or less deeply as the harrows may chance to take it; whereas the drill-machine deposits the seed in the soil at any depth the farmer chooses, and all the seed at the same depth, thereby giving him such a command over the position of the seed in the soil as no broadcast machine or hand-sowing can possibly do.

Broadcast Sowers.—There are various forms of the *broadcast* sowing-machine. The one illustrated in figs. 419 and 420, made by Ben. Reid & Co., Aberdeen, exhibits the machine in the most perfect form. This machine not only does the

work well, but it is so constructed that its long sowing-chest is divided into sections, the two end ones of which can be folded upon the central division, whereby it may pass through any field-gate

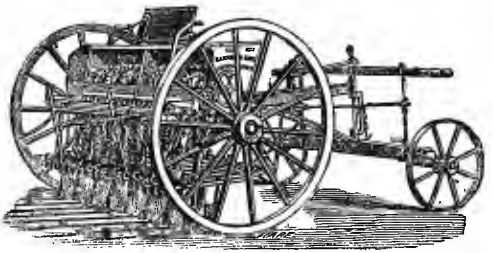


Fig. 421.—*Corn and seed drill.*

without the sowing-chest having to be removed. The *sowing-gear* of the broadcast machine is connected with the main axle of the carriage, as shown in the figure. The arrangements for regulating the quantity of seed per acre are very simple and effective, and altogether the machine is very easily worked and controlled. About 18 feet is the usual width sown at once by the machine.

Drill Sowers.—There are now many excellent seed-drills in the market, their general type being indicated by the representation of Garrett's drill in fig. 421. Ingenious and efficient devices are employed for regulating the quantity of seed per acre, the width of the drills,

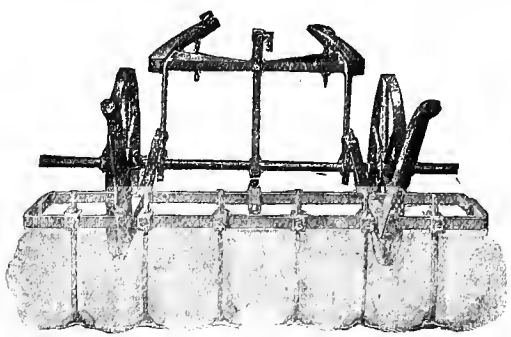


Fig. 422.—*Horse-hoe.*

and the depth to which the seeds are deposited.

By the use of the drill-machine less seed will thus suffice, and another advantage is that the land between the rows may be hoed by the hand-hoe, or by a horse-hoe, such as in fig. 422 (Martin, Stamford), thus tending to clean the land. Drilling is rightly enough in favour for good land in good heart, but on poor or medium land it does not give so much straw as broadcast sowing.

Width of Drill.—The width between the rows of wheat varies somewhat. On good land in high condition, 6 inches is a common width, but many consider that rather too great for ordinary land.

Hand Seed-drill.—There are useful small hand seed-drills both for grain and root crops, such as Boby's, which is represented in fig. 423.

Hand Broadcast Sowers.—Fig. 424 represents a very ingenious and most useful hand broadcast sower, the "Little Wonder," of American invention, and brought to this country by Mr J. H. Newton, West Derby, Liverpool. The illustration pretty well explains its appearance and action. A light box of thin wood is carried under the left arm with a strap over the shoulder. To the top part of this is attached a canvas receptacle for the seed, while on front and below is fixed a little tinned iron wheel, or rather four crossed pieces revolving on a spindle. Round this spindle is passed a thong which forms the string of a bow, and by "see-sawing" this bow the wheel revolves in alternate directions. An eccentric on the spindle moves a little hopper which keeps a regular stream of seed falling on to the revolving "wheel," and this in its turn sends the grain spinning out all round. It will cover a width of about 30 feet, but some have found it best in practice to go up the centre of one rig and down another, thus taking 14 or 16 feet at a time. It is thus possible, if kept supplied with seed, to do four acres per hour, while three is easy of

Fig. 423.—*Hand seed-drill.*

attainment. To ensure an even braird, the machine should be carried in a level position. It sows all kinds of grain admirably, and is equally well adapted for sowing dry artificial manure. The quantity to be sown per acre is regulated by a little slide.

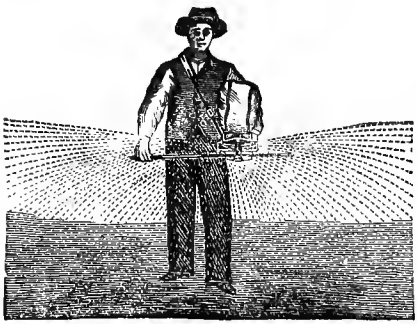


Fig. 424.—*Broadcast hand-sower.*

Strawson's ingenious air distributor may also be adapted for sowing grain broadcast.

Harrowing.

The land, whether sown by hand or with any sort of machine, must be harrowed. The order in time of using the harrows differs with the sort of machine used for sowing the grain. When the grain is sown by hand or with the broadcast machine, the harrow is used chiefly after the grain has been sown, although many consider it desirable to "break in" the surface by a single or double turn of the harrows before sowing. But in sowing with drill-machines, the harrow is first used to put the land into the proper tilth for the machine.

Considering the operation the *harrow* has to perform in covering the seeds that have been cast upon the soil, and reducing the surface-soil to a fine tilth, it is an implement of no small importance; and yet its effects are apparently rude and uncertain, while its construction is of the simplest order. So simple indeed is this construction, that at a very remote period it appears to have taken that form which, in so far as the simple principles of its action are concerned, is almost incapable of further improvement.

Iron Harrows.—Fig. 425 represents Howard's set of iron harrows for a pair

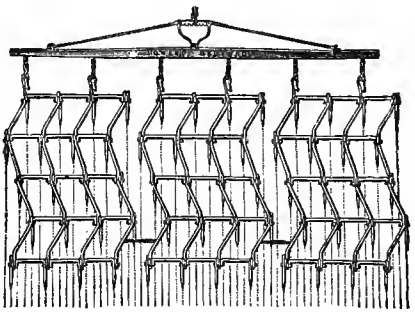


Fig. 425.—*English iron harrows.*

of horses. Sellar's harrows, suited for heavy land, are shown in fig. 426. Wooden harrows, once so common, are now out of date. Iron harrows are made of many patterns. Most of them are wonderfully durable, light in draught, and very effective in reducing the soil to a fine condition. They are made heavy or light, according to the work intended to be done. In some the teeth or tines are held in by screw and nut, and in others by being driven through holes of the required size.

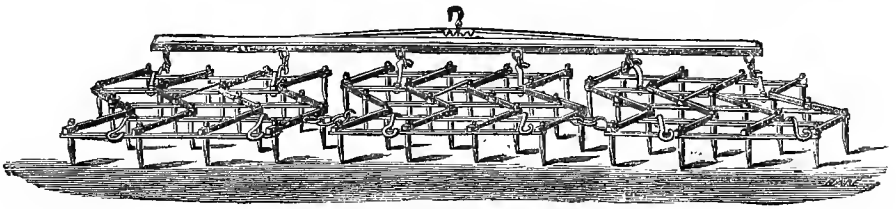


Fig. 426.—*Scottish iron harrows.*

Process of Harrowing.—Two pairs of harrows work best together. One pair takes the lead, by going usually on the near side of the ridge, while the other pair follows on the off side,

but the leader takes the side of the ridge whichever is nearest the open field. Each pair of harrows should be provided with double reins, one rein from each horse; and the ploughmen should be made to walk and drive their horses with the reins from behind the harrows. If a strict injunction is not laid upon them in this respect, the two men may be found walking together, the leading one behind the harrows, the other at the head of his horses. The latter is thus unable to know whether his harrows cover the ground which they ought to cover, and the two are more engrossed in talk than in the work in hand.

To draw harrows as they should be drawn is really not so light work for horses as it seems to be. When the tines are newly sharpened and long, and take a deep hold of the ground, the labour is considerable. To harrow the ground well—that is, to stir the soil so as to allow the seed to descend into it, and bring to the surface and pulverise all the larger clods, as in the case of broadcast sowing—requires the horses to go at a smart pace; and for efficient working harrows should on all occasions be driven with a quick motion.

When the seed is sown by a drill-machine, it is deposited at a given depth; and in order that the harrows shall not disturb its position, the land is harrowed fine before the seed is sown, a single tine — that is, one turn of the harrows — along the drills covering the seed sufficiently.

Cross-harrowing. — After the appointed piece of ground, whether a whole field or part, has been broken-in and sown, the land is *cross-harrowed* a double tine—that is, at right angles to the former harrowing, and to the ridges. But as, for this operation, the ground is not confined within the breadth of ridges, the harrows cover the ground with their whole breadth, and get over the work in less time than in breaking-in.

Cross-harrowing is not easy for the horses, inasmuch as the stripes left in the ground by the breaking-in have to be cut through, and the irregular motion of the harrows, in jerking across the open furrows of the ridges, has a fatiguing effect upon the horses.

To finish the harrowing, another double tine along the ridges, as in the case of the breaking-in, may be necessary. This turn is easily and quickly performed, the soil having been so often moved; and should it seem uniform in texture, a single tine will suffice for a good finishing.

Efficient Harrowing.—To judge of the harrowing of land, the sense of feeling is required as well as that of sight. When well done, the soil seems uniformly smooth, and the small clods lie loosely upon the surface,—the ground feeling uniformly consistent under the tread of the foot. When not sufficiently harrowed, the surface appears rough, the clods are half hid in the soil, and the ground feels unequal under the foot,—in some parts resisting its pressure, in others giving way to it too easily.

The old saying that "good harrowing is half farming" has more wisdom in it than at first sight appears. The *efficient harrowing* of land is of more importance than seems generally to be imagined. Its object is not merely to cover the seeds, but to pulverise the ground, and render it of a uniform texture. Uniformity of texture maintains in the soil a more equable temperature, not absorbing rain so fast, or admitting drought too easily, as is the case when the soil is rough and kept open by clods.

Whenever the texture becomes sufficiently fine and uniform, the harrowing should cease, although the appointed number of double or single tines has not been given; for it is a fact, especially in light, soft soils, that over-harrowing brings part of the seed up again to the surface.

Water-furrows.—When the spring wheat was sown early in the season, in January or near the end of February, it was usually considered necessary in former times that the ridges should be *water-furrowed*, so that, in case of much rain falling or snow melting, it might run off the surface of the ground by the water-furrows. Where the spring wheat was sown late in the spring, in the end of February or beginning of March, the water-furrowing was not executed until after the sowing of the grass-seeds, if any were to be sown with the wheat crop.

Water-furrowing is making a slight plough-furrow in every open furrow, as

a channel for rain-water to flow off the land. It may be executed lightly with a common plough and one horse, but better with a double mould-board plough and one horse; and as the single horse walks in the open furrow, the plough following obliterates his footmarks.

The better water-furrowing by the double mould-board plough consists in the channel having equal sides; and the furrow-slice on each side being small, compared with the one-furrow slice of the common plough on one side, the water can run more freely into the furrow. The plough simply goes up one open furrow and down another until the field is finished, the horse being *hied* at the turns into the open furrow. Water-furrowing finishes the work of the field.

Under-drainage *v.* **Water-furrows.**—On average soils there will be no necessity for water-furrows if the land is thoroughly under-drained. The importance of this latter is now universally acknowledged, and great benefit has been derived by the large extent to which drainage has been executed throughout the country. When the soil is exceptionally adhesive, and water apt to lie in pools on its surface, it is very desirable that water-furrows should be provided to prevent this.

Wheat after Grass.—The foregoing relates mainly to the sowing of wheat after a root crop. But a large extent of spring wheat is also sown after grass, chiefly in England, and some of the earlier and drier districts of Scotland. The success of spring wheat after grass in England attests the superiority of the English climate, which is too dry, and too warm in the southern counties, for the perfect growth of oats. A great obstacle to sowing wheat in Scotland in spring is the action of two classes of soil on the growth of that plant. Clay soils are too inert in the average climate of Scotland to mature the growth of wheat in a few months; and the light soils, though more favourable to quick vegetation, want stamina to support the wheat plant, and are, besides, too easily affected by drought in early spring—it being no uncommon occurrence in Scotland to experience a severe drought in March, and during the prevailing east wind.

Wheat cannot be safely sown in the autumn in Scotland after the end of October, which is the time for sowing after potatoes. Some sow it in November, to the risk of producing a thin crop. To plough up lea before October would be to partially sacrifice the aftermath. Many farmers do this rather than lose the advantage of sowing wheat in good time before the winter sets in. But with others the aftermath is of greater importance, and they accordingly defer the ploughing of the lea till winter, and the sowing of the wheat till spring. January is considered a good month for wheat-sowing, but it is only in exceptional seasons and in favoured districts that the weather permits of this. There is thus a considerable extent of spring wheat sown after grass.

Varieties of Spring Wheat.

As to the varieties of wheat which should be sown in spring in different localities, it would be imprudent to dogmatise. With the great attention now being given to the improvement of farm plants, and to the bringing out of new varieties and stocks of exceptional vigour and power of production, it is quite probable that the variety which is considered best to-day will be excelled in the near future. Farmers must therefore be constantly on the outlook for improved sorts, and be guided by the experience of the time as to which variety they should select.

It is this same consideration—the great ingenuity and enterprise employed in developing new sorts, and the rapidity with which one good sort is supplanted by a still better—which influenced us in deciding not to attempt in this work a detailed description of the different varieties or sorts of the respective farm crops now in use in this country.

For guidance as to the best varieties to use, no farmer need have any difficulty. By a careful study of the experience of other farmers, and due consideration of his own peculiar conditions as to soil and climate, he is not likely to be far wrong as to the selection of varieties.

Of course, care must be taken not to sow a *distinctly winter* variety of wheat in spring. As to a winter wheat no mistake can be made, for however early may be the habit of the variety sown, the

very circumstance of its being sown in autumn, when sufficient time is not given to the plant to reach maturity before winter, will convert it for that season into a winter variety. The wheat plant is a true annual, but when sown late, and the progress of its growth is retarded by a depression of temperature, it is converted for the time into a biennial. It is therefore highly probable that, as the nature of wheat is to bring its seed to maturity in the course of one season, any variety sown in time in spring would mature its seed in the course of the ensuing summer or autumn. This is believed to be a fact; nevertheless, circumstances may occur to modify the fact *in this climate*. Under the most favourable circumstances, the wheat plant requires a considerable time to mature its seed; and a variety that has long been cultivated in winter, on being sown in spring in the same latitude, will not mature its seed that season should the temperature fall much below the average, or should it be cultivated on very inferior soil to that to which it had been accustomed. In practice, therefore, it is not safe—at least in so precarious a climate as that of Scotland—to sow *every variety* of wheat in spring.

Spring Wheat-seed from Early Districts.—Wheat taken from a warm to a cold climate will prove earlier there than the native varieties, and, in so far, better suited for sowing in spring; and if the same variety is an early one in the warm latitude—bringing its seed to maturity in a short period, perhaps not exceeding 4 months,—then it may safely be sown as a spring wheat, whether it be red or white, bearded or beardless.

The long experience of the late Mr Patrick Sheriff, East Lothian, led him to the conclusion that autumn wheats should not be sown in spring, as they will not produce a sufficient number of prolific ears.

Late Varieties of Wheat.—Special attention has been given in recent years to the bringing out of varieties of wheat suitable for sowing late in spring. Considerable success has been attained, and there are varieties now in use which in average years give fairly satisfactory results, although not sown till March or April.

As to the quantity of seed for wheat per acre, information is given on page 118, as also in the section on "The Germination of Seeds" in this volume.

Manuring Wheat.

In the description of the Rothamsted experiments in pages 1-32 of this volume, much useful and suggestive information as to the manuring of wheat will be found. Wheat is usually sown on land in good heart, for the most part after a potato or root crop, with which a heavy dressing of dung and artificial manure had been applied. In this case no special application of manure may be necessary for the wheat beyond perhaps a top-dressing with a little ammonia-salts or nitrate of soda in spring. The sulphate of ammonia may be sown at the same time as the seed for the spring wheat, or early in spring for winter wheat, but nitrate of soda should not be sown until the plants are able to immediately assimilate the manure. From 1 to 2 cwt. per acre are common quantities of these fertilisers for top-dressing wheat.

When the land has not been liberally manured with the preceding crop, a heavier dressing, including phosphatic and potassic manures, must be given to the wheat crop; or it may be manured with dung. See chapter on "Manures and Manuring."

Summer Culture of Wheat.

The amount of attention which the wheat fields demand in the summer months depends mainly upon the time they had been sown.

Autumn Wheat.—Autumn or winter sown wheat may be too far advanced in growth before the advent of summer to permit of any cultural work being given to it in that season. Such horse-hoeing or harrowing as it may require will therefore be performed in spring. The state of the autumn-sown wheat in summer depends on the weather in winter and spring, and the nature and condition of the soil upon which it was sown.

Over-luxuriance in Autumn Wheat.—Mild weather in winter will cause it to grow luxuriantly; and if the mildness continue till spring, the plants may, from over-luxuriance, lie down in spring, and become blanched and rotted at the roots.

In the early part of winter, if the ground is dry, sheep may eat down luxuriant wheat to a considerable degree. Even if not folded on it, sheep will do much good to luxuriant wheat by trampling upon it for a while every day, and eating off the tops of the plants.

But the winter luxuriance is frequently checked, and even the plants destroyed, by severe frosts at night and bright sunshine during the day in March. Should the winter luxuriance continue till spring, sheep cannot then crop it uniformly, and should not be allowed to attempt it. If luxuriance only commenced in spring, sheep can restrain it then as well as in winter.

Cropping Rank Wheat.—The winter luxuriance can be restrained in spring only by mechanical means—by cutting off the tops with the scythe. This may be done safely until the plant puts forth the shoot-blade, perhaps as late as the end of April. Before commencing cropping with the scythe, some of the most forward plants should be opened to ascertain the position and length of the ear, which should not be touched. The leaves cut off lie on the ground to decay. The advantage of cropping wheat when over-luxuriant is, that rain will no longer hang upon it, and air and light will have access to the stem to strengthen and support it. The risk of lodging is thereby greatly lessened. Spring wheat rarely becomes too luxuriant in summer, and requires no expedient to check its growth.

Soil and Over-luxuriance.—Of the classes of soil which produce over-luxuriance, dry deep clay loam is most apt to do it in a mild autumn and winter; and thin clay land, upon a retentive wet subsoil, is most liable to destroy wheat in March. Even when showing no luxuriance, and the crop promising, yet by the injurious effects of March weather the plants may not only be sickly and scanty, but too late to tiller.

Weeding.—The weeding of the cereal crops in summer where the land is foul is an indispensable work for their welfare. If the crop should be too far advanced to permit horse labour, the weeding must be done solely by the hand or with manual implements; if not, both manual and horse implements may be employed,—that is, where the seed has been sown in drills. Among broadcast grain, weeding must be performed by the hand and with manual implements. An effective tool for this purpose is the simple weed-hook, fig. 427. It consists of an acute hook of iron, the two inner edges of which are flattened and thinned to cut like a knife, and which are as far asunder at one end as to embrace the stem of succulent herbaceous plants which are destined to be cut down. The cutting-hook is attached to a socket, which takes in the end of a light wooden shaft about 4 feet in length, which is fastened to it with a nail or screw, the hook having such a bend as that its under surface shall rest upon the ground, while the worker uses the shaft in a standing position. A sharp spud with a cross-head handle is the best instrument for cutting weeds with strong stems—as docks, thistles—with a push.

Fig. 427.—*Weed-hook.*

The best way for field-workers to arrange themselves, when weeding broadcast corn, is for two to take one ridge, each clearing one-half of the ridge from the open furrow to the crown. On weeding amongst corn, the point of the weed-hook is insinuated between the stems of corn toward the weed to be cut, and on its stem being taken into the sharp cleft of the hook at the ground, it is easily severed by a slanting cut upwards towards the worker. The weeds, cut over, are left on the ground to decay; but no weed should be allowed to grow *beyond* the time of its flowering. Docks should be pulled up by the root and carried away and burned.

Hoeing Drilled Wheat. — Wheat sown in rows may be weeded with the hand-hoe, or with horse-hoes. The hand-hoe is used by field-workers, who each take one row between the drills. To prevent jostling, the worker in the centre of the band takes the lead in advance

position, while the others follow on each side in echelon. Where drilled crops occupy much extent of ground, the ordinary number of hand-hoers are unable to clear the weeds before the crops advance too far to go amongst them. Hence the need of the more expeditious horse-hoe (fig. 422).

The horse-hoeing of corn should be intrusted to a careful man and a steady horse. A steady horse will not leave the row he walks in from end to end of the landing. A young horse is unsuited for this work. A careful man to steer the hoes is as requisite as a steady horse; otherwise the hoes may run through the rows of corn-plants, tearing them up as well as the weeds.

As already indicated, to wheat sown in the preceding autumn or winter this horse-hoeing has usually to be given in spring,—that is, if given at all.

Top-dressing Wheat.—If the crop is not making satisfactory progress, or if it is considered desirable for any reason to top-dress wheat late in the season, this may be done during the month of May. Mild moist weather is most suitable for the process. At this late period of the season a dressing of nitrate of soda, perhaps from 1 to 2 cwt. per acre, would likely give the best result. Some would add 2 cwt. of superphosphate. It is considered a good plan to delay a portion of the more quickly acting manures to be sown as a top-dressing in this way.

Flowering Season.—The flowering season is critical for wheat, since a difference in the weather of June may affect the yield to upwards of 50 per cent. Should the weather be rainy and windy in the flowering season, the produce will inevitably be scanty. Rain alone, unless of long duration, does not affect the produce as much as strong wind, which seriously injures the side of the ear exposed to it. Showers and gentle breezes do no harm; but sunshine, heat, and calm are the best securities for a full crop.

PICKLING WHEAT.

There is much to be said in favour of the pickling of seed-wheat—that is, subjecting it to a preparation in a certain kind of liquor—before it is sown. This treatment assists greatly in protecting the crop against the attack of a fungoid disease in the ensuing summer called *smut*, which renders the grain comparatively worthless. Some farmers affect to despise this precaution, as originating in an unfounded reliance on an imaginary specific. But the existence of smut and its baneful effect upon the wheat crop are no imaginary evils; and when experience has proved, in numberless instances, that steeped seed protects the crop from this serious disease, the small trouble and expense which pickling imposes may surely be incurred, even although it should fail to secure the crop.

Various methods and materials for pickling are employed. A solution of blue vitriol is largely used, and the process, as described in former editions of this work, is seen in fig. 428. Care must be taken not to have the "pickle" so strong as to retard or prevent germination. One pound of copper sulphate to a gallon of water would suffice for four bushels of seed.

Fig. 428.—*Apparatus for pickling wheat.*

a Sackful of wheat.
b Basket to receive the wheat from the sack.
c Tub of pickle.
d Basket of pickled wheat.
e Drainer for basket.
f Tub to receive draining of pickle from the basket.
g Heap of pickled wheat.
h Sacks for the pickled wheat.

The pickling may be done on the corn-barn floor. Two upright baskets are provided, each capable of holding easily about half a bushel of wheat, having upright handles above the rims. Pour the wheat into one basket from the sack, and dip the basketful of wheat into the tub of vitriol completely to cover the wheat, the upright handles protecting the hands from the vitriol. After it remains in the liquid for a few seconds, lift up the basket, so as to let the surplus liquid

run from it into the tub again, and then place the basket upon the drainer on the empty tub, to drip still more liquid, until the other basket is filled with wheat and dipped in the vitriol tub. Then empty the dripped basket of its wheat on the floor, and as every basketful is emptied, let a person spread, by riddling it through a wheat-riddle, a little slaked caustic lime upon the wet wheat to dry it. Thus all the wheat wanted at the time is pickled and emptied on the floor in a heap.

Turning Pickled Wheat.—The pickled and limed heap of wheat is turned over and mixed in this way: Let two men be each provided with a square-mouthed shovel, one on each side of the heap, one having the helve of his shovel in his right hand, and the other in his left; and let both make their shovels meet upon the floor, under one end of the heap of wheat, turning each shovelful from the heap behind them, till the other end of the heap is reached. Let them return in a similar manner in the opposite direction, and continue, until the wheat is thoroughly mixed and dried with the lime. The pickled wheat is then sacked up, and carried to the field in carts.

SOWING BARLEY.

It may be laid down as an axiom that the seed-bed upon which barley is to be sown should be fine, moderately deep, and clean, with an abundant supply of all the ingredients necessary for the growth of the plant present in a soluble or readily available form. In Scotland land after turnips is the place in the rotation which is generally set aside for the growth of barley. In England barley is largely grown after either wheat or oats, especially on farms where the turnips are consumed on the ground by sheep to which cake or grain is given.

Tillage for Barley.—If the land is not of the heavy order of soils, all that is necessary is the ordinary ploughing, especially if it can be accomplished by the second week of February. The action of the weather and frost will break down and mellow the soil, rendering it friable, so that a double tine of the harrows before putting in the seed is all that is needed to obtain a seed-bed in good tilth. On the heavier class of soils, and where ploughing cannot be done until later, more especially where the turnip crop has been eaten off by sheep, two ploughings may be necessary as well as harrowing before seeding.

But the simplest and easiest mode of procedure is to plough the land with one of the new Anglo-American ploughs, which will break down the furrow, leave the land level, and in excellent tilth. By this plan the old method of cross-ploughing, scarifying, grubbing, ribbing, &c., may be obviated.

It is probable that some of the turnip-land which may have been ploughed for spring wheat may have to be sown with barley, on account of inclement weather preventing the sowing of wheat in seasonable time. In that case, whether the land had been gathered up from the flat or cast together, it should be seed-furrowed in the same form for the barley, to retain the uniform ridging of the field; for the ploughing for spring wheat being the seed-furrow, and the ridges made permanent, it would be impossible to reverse the ploughing with one furrow, without leaving one ridge on each side of the field half the width of the rest. The ridges would have to be ploughed *twice* to bring them back to their proper form, but for which there could not be time, so they must be stirred with the grubber, or ribbed with the small plough.

Another method which is being adopted by farmers is to plough the land after turnips, in breaks of six ridges, gathering four and splitting two. This has become advisable nowadays, owing to the advent of the reaper, for which the old open furrows were very unhandy, while the crop was uneven, as the growth on the crown of the ridge was heavier than that in the furrow which divided the ridges.

If the ridges have consolidated on being long ploughed, the grubber will make a suitable bed for the barley seed, and keep the dry surface uppermost. If the soil is dry and loose on the surface, and tilly below, it will be best preserved by ribbing with the small plough.

By putting such ridges thus into the best state for barley, there will be no

difficulty in ploughing the rest of the land. The first furrow upon the trampled soil should be the *cross*-furrow.

Sowing.—Sowing barley upon a fine evenly pulverised surface requires strict attention, inasmuch as on whatever spot every seed falls, there it lies, the soft earth having no elasticity to make the seed rebound and settle on another spot. Hence, of all sorts of corn, barley is the most likely to be striped in sowing by hand, so every handful must be cast with great force. Walking on soft ground in sowing barley is attended with considerable fatigue. Short steps are best suited for walking upon soft ground, and small handfuls are best for grasping plump slippery barley.

The broadcast machine sows barley as well as oats on the ploughed surface, and so do the corn-drills across the ridges after the surface has been harrowed. The grubbed surface is best sown by a drill-machine, affording the seed a firm hold of the ground, while the surface ribbed with the small plough is best sown by hand, or with the broadcast machine, the seeds falling into the ribs, from which the young plants rise in rows, the ground being harrowed only a double tine along the ribs. Barley may be sown any time fit for spring wheat, and as late as the month of May. But the earlier crop will be of better quality and more uniform, though the straw may be shorter.

Quantity of Seed.—The quantity of seed sown broadcast is from 2½ to 4 bushels to the acre. When sown early, less suffices; when late, more is required, because less time is given to tiller and cover the ground. Sown with the drill, 2 bushels suffice.

Brown makes some sensible remarks on this subject. "Amongst the farmers," he says, "it seems a disputed point, whether the practice of giving so small a quantity of seed (3 bushels per acre) to the best lands is advantageous. That there is a saving of grain, there can be no doubt; and that the bulk may be as great as if more seed had been sown, there can be as little question. Little argument, however, is necessary to prove that thin sowing of barley must be attended with considerable disadvantage; for if the early part of the season be dry, the plants will not only be stinted in their growth, but will not send out offsets; and if rain afterwards falls—an occurrence that must take place some time during the summer, often at a late period of it—the plants *then begin to stool*, and send out a number of young shoots. These young shoots, unless under very favourable circumstances, cannot be expected to arrive at maturity; or if their ripening is waited for, there will be great risk of losing the early part of the crop—a circumstance that frequently happens. In almost every instance an unequal sample is produced, and the grain is for the most part of inferior quality. By good judges it is thought preferable to sow a quantity of seed sufficient to ensure a full crop without depending on its sending out offsets. Indeed, when that is done, few offsets are produced—the crop grows and ripens equally, and the grain is uniformly good."[1]

Still, too thick sowing should be avoided, for it is liable to produce weak straw, and consequently a greater tendency to lodging.

Germination of Barley and the Weather.—No grain is so much affected by weather at seed-time as barley. A dash of rain on strong land is liable to cause the crop to be thin, many of the seeds failing to germinate. In moist, warm weather, the germination is certain and rapid. It has been observed that unless barley germinate quickly the crop will be thin.

Harrowing for Barley.—The harrowing required for barley land sown broadcast is generally less than for oat land, a double tine being given in breaking-in the seed, and a double tine across immediately after. When sown with the drill-machine, the harrowing is perhaps a double tine along and double tine across the ridges, before the seed is sown. When sown on ribbed land, the only harrowing may be a double tine along the ribs, just to cover the seed, as the ribs afford it a sufficient hold of the ground. Care, however, should be taken in all cases to ensure a fine even seed-bed for barley. The condition of the land will be the best guide as to the amount of harrowing required in individual cases.

When barley is grown on fairly strong land after roots consumed on the ground

[1] Brown's *Rur. Aff.*, ii. 45.

by sheep, extra harrowing may be required.

Finishing.—The grass seeds are then sown with the grass-seed sowing-machine; the land harrowed a single tine with the light grass-seed harrows, and thereupon finished by immediate rolling. On strong land, apt to be incrusted on the surface by drought after rain, rolling may *precede the sowing of grass seeds*, and the work is finished with the grass-seed harrows, and perhaps another turn of the roller. On all kindly soils rolling is usually the last operation.

Soil for Barley.—Medium and light loams of a calcareous and friable nature —such as are generally known as good turnip lands — are best adapted to barley.

Barley does not stand the winter in Scotland as it does in the warm calcareous soils of the south of England. Winter barley is early ripe, and prolific; but if the weather causes it to tiller in spring, it produces an unequal sample, containing a large proportion of light grain.

Varieties of Barley.—The varieties of barley are numerous. They are generally distinguished by the shape of the ear and the number of rows of grain which grow upon the ear.

Uses of Barley.—The great bulk of the better samples of barley is used for distillery purposes, a small proportion being employed for the manufacture of pot barley or barley-meal, chiefly confined for use in Scotland. The inferior or damaged barley is used as food for animals.

Manuring Barley.

When it follows a well-manured root crop, as it generally does in Scotland, barley seldom requires or receives any further manuring. Barley is a suitable crop for land on which a portion of the root crop has been consumed by sheep, and in this case the soil is usually in good heart, especially if the sheep have been allowed extra food, such as cake or grain along with the roots. The custom is to plough this land with a light or moderate furrow, and thus give the barley an abundance of readily available plant-food within the reach of its shallow roots.

But when the land has not, by previous treatment, become sufficiently stored with fertility for barley, this crop will, as a rule, respond satisfactorily to direct dressings of suitable manure. Being a rapid-growing shallow-rooted plant, barley should have plenty of readily available food within easy reach of the surface. Quickly acting artificial manures are thus specially suited for barley. Superphosphate and nitrate of soda, or sulphate of ammonia, in different quantities and proportions, according to the character and condition of the land, are extensively and advantageously used as top-dressing for barley. The first and last should be applied at seed-time; nitrate of soda, which acts more rapidly than sulphate of ammonia, may be applied in moist weather a few weeks later. Common quantities, per acre, are 2 to 3 cwt. superphosphate, and ½ to 1 cwt. of the nitrogenous manure. In many cases a light dressing of sulphate of ammonia or nitrate of soda is found to be very effective alone. In other cases a combined dressing of phosphatic, nitrogenous, and potassic manures gives the best results.

Rothamsted Barley Experiments.

The experiments on the manuring of barley at Rothamsted are full of interest to farmers. They have gone on continuously since 1852, and are capable of teaching some important lessons. Briefly summarised, the results are as follows:—

No Manure.—The plot which has had no manure of any kind since the beginning of the experiments gave an average of 17⅞ bushels for the thirty-two years up to 1883—4½ bushels less than the average of the first ten years.

Farmyard Dung.—Applied at the rate of 14 tons every year for thirty-two years, this gave for that period an average of 49½ bushels, or about 31½ over the unmanured plot.

Mineral Manures.—Mineral manures alone—that is, superphosphate of lime, and sulphates of potash, soda, and magnesia—gave very poor crops, both of grain and straw. Superphosphate alone, on an average of the thirty-two years, gave only about 5 bushels more than the plot with no manure; the increase from potash, soda, and magnesia over no manure was barely 2 bushels per acre, and from all

these mineral manures combined scarcely 6 bushels.

Nitrogenous Manures.—These supplied in sulphate of ammonia or nitrate of soda gave more than double the increase produced by the mineral manures. Ammonia-salts, 200 lb. per acre (containing 43 lb. nitrogen), gave an average of 30¾ bushels for the thirty-two years—nearly 13 bushels over the unmanured plot. Nitrate of soda, 275 lb. per acre (containing 43 lb. nitrogen), gave nearly 4 bushels more per acre. *Rape-cake*, 1000 lb. per acre, calculated to yield 49 lb. of nitrogen, raised the produce to 43¼ bushels.

Nitrogenous and Mineral Manures combined.—These in combination produced excellent crops, more than the average of the country, continuously for thirty-two years. This result is very interesting, showing that barley responds admirably to the influence of readily acting artificial manures. Equal quantities of nitrogenous and mineral manures applied in the autumn to wheat, and in spring to barley, gave considerably more produce from the latter crop than the former.

Practical Conclusions.—From the results of the experiments with various manures for barley, it is inferred that in corn-growing the soil is most rapidly exhausted of its nitrogen, next of phosphates, and most slowly of potash. Nitrogenous manures are thus the first essential, but, especially for barley, phosphatic manures are also required, and give a good return. To most soils of a clayey tendency, dressings of potash will be unnecessary for cereals; but where it is deficient, a small allowance may be expected to exercise a wonderful influence on the crop. Here, as in general farm practice, it was found that superphosphate is more effective with the spring-sown than with the autumn-sown cereals.

Barley after Corn.—In reference to the practice of growing barley after a crop of wheat, Dr Fream says:[1] "It may be laid down as a general rule, applicable to the country at large, that, on the heavier soils, full crops of barley of good quality may be grown with great certainty after a preceding corn crop, under the following conditions: The land should be got into good tilth. It should be ploughed up when dry, as soon as practicable after the removal of the preceding crop. In the spring it should be prepared for sowing by ploughing or scuffling, as early in March as possible, if sufficiently dry. The artificial manure employed should contain nitrogen, as ammonia or nitrate (or organic matter), and phosphates. From 40 lb. to 50 lb. of ammonia (or its equivalent of nitrogen as nitrate) should be applied per acre. These quantities would be supplied in 1½ cwt. to 2 cwt. of sulphate of ammonia, or 1¾ cwt. to 2¼ cwt. of nitrate of soda. With either of these there should be employed 2 cwt. to 3 cwt. mineral superphosphate of lime. Rape-cake is also a good manure for barley; from 6 cwt. to 8 cwt. would supply about as much nitrogen as would be equal to from 40 lb. to 50 lb. of ammonia. With this manure, as with guano, the addition of superphosphate is unnecessary. Whatever manure be used, it should be broken up, finely sifted, sown broadcast, and harrowed in with the seed."

Quality of Barley after Roots.—Interesting trials on the quality of barley grown after roots were conducted by the Agricultural College at Wye, Kent. The results indicated that a dressing of salt is detrimental to the value of the barley, and that sulphate of potash, though increasing the starch content of the barley, did not give any commercial return, whilst a dressing of 3 cwt. of superphosphate per acre produced a slight increase in yield and a marked increase in quality. Determinations of the chemical composition of English barleys led to the conclusion that high quality in barley is linked with a high starch and low proteid content, factors which are not readily attained when barley is grown after roots which have been consumed on the land by sheep.

Superphosphate for Barley.—Trials conducted by the Wye Agricultural College showed the effect of superphosphate on the barley crop to be substantial. Without increasing the straw a dressing of from 3 to 5 cwt. per acre produced a marked improvement in the grain, the gross yield being increased, and the quality—as indicated by the weight per bushel, the proportion of flinty corns,

[1] *Rothamsted Experiments*, 120.

the amount of tail corn, and the albuminoid content of the grain—beneficially modified. In a year of severe drought it was found that the heavy dressings of superphosphate ripened off the corn too soon, both quality and quantity suffering.

Yorkshire Trials in Manuring Barley.

In the East Riding of Yorkshire barley of very good malting quality is grown over a wide area on what are known as the wold soils. These soils overlie chalk and are of light character very suitable for the fattening of sheep and for the growth of corn. As a rule the rotation followed is the following, viz.:—

Roots.
Barley or oats.
"Seeds" (clover mixture).
Wheat.
Barley or oats.

The land for roots as a rule receives no dung, but the crop is grown by means of artificial manures, and a part, or whole, of the crop is eaten on the land by sheep. The sheep receive some artificial food in the shape of cake and corn, and consequently the land is left in a condition that enables a satisfactory crop of corn to be grown. The "seeds," as a rule, are grazed by sheep, and during summer or early autumn dung is applied, and a good crop of autumn-sown wheat is secured in the following year. At this stage of the rotation, especially after a good crop of wheat, it is sometimes considered that for a crop of barley the land should receive some artificial manure. It therefore becomes a question as to what artificial manure might profitably be employed. To gain information on this point, experiments were planned and conducted by the Agricultural Department of Leeds University. Arrangements were also made for the barley grown by means of different artificial manures to be malted, so that it might be possible to determine if the manures had any effect upon malting quality.

The results have shown that for the growth of barley as a second corn crop and on the soils indicated above, it is necessary that there be supplied a soluble nitrogenous manure, and further that nitrate of soda is a much more profitable source of nitrogen than sulphate of ammonia.

Although the nitrogenous is the important manure to use, still, profitable results followed when nitrate of soda was accompanied by superphosphate and kainit. The following may be taken as the mixture that, as a rule, could be depended upon to give profitable results, viz.:—

1 cwt. Nitrate of Soda
2 cwt. Superphosphate } per acre.
2 cwt. Kainit

The average profit per acre by the use of the above mixture in nine experiments was 17s. 10d.

As regards the effect of the manures upon the malting quality of the barley, it has been found that in the best barley season during the period in which the experiments were conducted, the finest malting barley was grown with the aid of the above-mentioned mixture.

Summer Culture of Barley.

Such weeding and hoeing as the barley may require is usually given as in the case of wheat.

Destroying Charlock.—This is one of the most troublesome weeds amongst corn crops. It is known variously as skellock, runch, karlock, yellows, and wild mustard (*Brassica Sinapis*, Vis., *B. Sinapistrum*, Boiss., *Sinapis arvensis*, L.). It is allied to the turnip, which it resembles in appearance. It produces an oily seed, which can lie dormant under grass for years and spring into life when the ground is again broken up.

It is now found that charlock can be effectively kept in check amongst corn by spraying with solutions of sulphate of copper. The dressing most generally employed is 50 gallons per acre of a 3 per cent solution of copper sulphate, not less than 98 per cent purity. For the making of this solution the following is a simple rule: A gallon of water weighs 10 lb., 10 gallons of water weigh 100 lb., and 3 lb. of copper sulphate added to this give approximately a 3 per cent solution. To make sufficient fluid for one acre, 15 lb. of copper should be mixed in 50 gallons of clean water. In some cases a stronger solution (4 or 5 per cent) is found more effective.

Spraying should be carried out when the plants are about three inches in height, in any case before flowering begins. The solution is sprayed over the plants on a calm day by a hand or horse power machine. The spraying is most effective in dull weather. Heavy rain immediately after the spraying lessens its effectiveness, and may necessitate a second spraying. In any case, a second spraying within about ten days of the first may be required to complete the cure.

Many wonder why it is that while this poisonous solution kills the charlock it does no harm to the corn. The reason is supposed to be that the leaves of the charlock, being rough in surface and horizontally disposed, catch and hold the poison, whereas the leaves of the corn, being smooth and erect, let the fluid run off quickly, thus escaping injury.

Top-dressing Barley.—Barley may be top-dressed like wheat. From 1 to 2 cwt. of nitrate of soda and 2 cwt. superphosphate would be a good late dressing.

SOWING OATS.

The oat is by far the most extensively grown of the cereal crops in Scotland and Ireland. In England oats are grown extensively after turnips or mangels. And in all northern and high-lying districts unfavourable for the ripening of wheat or barley, oats are the prevailing crop after turnips.

Oats are sown on all sorts of farms, from the strongest clay to the lightest sand, and from the highest point to which arable culture has reached on moorland soil to the bottom of the lowest valley on the richest deposit. The extensive breadth of its culture does not imply that the oat is naturally suited to all soils and situations, for its fibrous and spreading roots indicate a predilection for friable soils; but its use as food among the agricultural population generally, and its suitability to support the strength of horses, have induced its extensive cultivation.

Varieties of Oats.—The oat plant thrives best in a cold climate, and is grown in the chief countries lying in the temperate zone. It comes to its greatest perfection in Scotland. This is to a certain extent due to the climate, but the care which many Scottish farmers give to the oat crop also contributes to this result. The varieties which occupy the greatest breadth are the Common Improved or White oats, and to a lesser extent Black or Tartarian. Common oat is the name by which farmers designate the variety which is commonly grown in the respective districts in which they farm.

The following are the chief varieties: The Potato, Poland, Angus, Hopetoun, Sandy, Tartarian, Tam Finlay, Hamilton, Longhoughton, Canadian oats, Swiss oat, &c.

Sowing.—The sowing of the oat seed is begun with the common varieties of oats about the beginning of March. It is the custom in some parts to sow the improved varieties a fortnight after the common. The ploughed lea ground should be dry on the surface before it is sown, as otherwise it will not harrow kindly; but the colour of dryness should be distinguished from that arising from dry hard frost, a state improper to be sown upon. Every spot of the field need not be alike dry—even thorough draining will not ensure that, though spots of wet indicate where dampness in the subsoil exists.

Harrowing before Sowing.—Should the lea have been ploughed some time and from young grass, the furrow-slices will lie close together at seed-time; but when recently ploughed, or from old lea, or on clay land in a rather wet state, the furrow-slices may be as far asunder as to allow a good deal of the seed to drop down between them, and thus be lost, as oats will not vegetate beyond 6 or 7 inches deep in the soil. In such states the ground should receive a double tine or strip of the harrow before being sown. This should be done in every case unless the furrows are small and packed quite closely.

When oats are sown by hand upon dry lea ground, the grains rebound from the ground and dance about before depositing themselves in the hollows, in rows, accommodating themselves between the crests of the furrow-slices, and do not so

readily show bad sowing as upon a smooth surface. Were the ground harrowed along the ridges, so as not to disturb the seed in the furrow-slices, the crop would come up as if sown by drill; but as the land is cross-harrowed, the braird comes up to some extent broadcast.

Quantity of Seed.—The quantity of common oats usually sown is from 4 to 5 bushels per acre. In deep friable land in good heart, and in early districts, from 3 to 4 bushels of the best tillering varieties is considered sufficient seed.

A man does a good day's work if he sows broadcast by one hand 16 imperial acres of ground in ten hours. Some men can sow 20 acres; and double-handed sowers will do even more than 20 acres.

Number of Seeds per Acre.—In experiments on different varieties of oats conducted by the West of Scotland Agricultural College, it was decided to regulate the quantity of seed to be sown by the number of seeds per acre instead of by measure. In the first year 2,500,000 seeds of each variety were sown per acre, but except on rich soils, the plants from this seeding were too thin, and in after years the number of seeds was increased to 3,000,000 per acre. The weights of seed required of the different varieties included in the trials to supply this number of seeds per acre were as follows:—

Variety.	Average Quantity of Seed required to supply 3,000,000 Seeds.
	lb.
Sandy	194
Potato	212
Banner	252½
Waverley	258
Wide Awake	267½

It is thus seen that approximately about ½ bushel per acre more Potato oat and 1½ bushel more of the Banner oat were required than of the Sandy oat in order to supply the 3,000,000 seeds per acre.

Harrowing after Sowing. — The tines of the harrows should be particularly sharp when covering in seed upon lea. After the land is broken in with a double tine, it is harrowed across with a double tine, which cuts across the furrow-crests, and then along another double tine, and this quantity commonly suffices. At the last harrowing the tines should be kept clean from grassy tufts, and no stones should be allowed to be dragged along by the tines, to the injurious rubbing of the surface. On old lea, or hard land, another single tine across or angleways may be required to render the surface fine; and, on the other hand, on light soil a single tine along after the double one across may suffice. In short, the harrowing should be continued until the ground seems uniformly smooth and feels firm under the foot. The head-ridges are harrowed by themselves at the last.

Water-furrows.—If the land is liable to suffer from surface-water, water-furrows may be formed in the open furrow, after sowing. But with underground drainage now so general and thorough, this practice has become almost a thing of the past.

Machine-sowing. — Almost every farm with two or more pairs of horses, and even smaller holdings, has its broadcast or drill sowing-machine. Hand-sowing is thus being replaced by the machine. The practice in sowing oats with machines, whether broadcast or drill, is similar to that in sowing wheat and barley. To enable the drill to make good work in sowing on ploughed lea, the surface must be well broken up with the harrow. Where the surface is rough, and the furrows tough, the broadcast machine would be preferable.

Ploughing for Oats.—Difference of opinion exists as to the depth to which lea ground should be ploughed for oats. One opinion is that a depth of 4 inches is sufficient, with the furrow-slices laid down close; others contend that the land should be ploughed 9 inches in depth, and not laid over close. To determine which opinion is the more correct, it should be taken into account that the roots of oats are fibrous, and permeate through the soil to a greater depth than the roots of barley. This being their character, a good depth of furrow will be best for oats. Much of course will depend upon the depth and the character of the soil and of the subsoil; but as a rule, it is considered undesirable to plough lea shallower than 7 inches, to afford a

considerable amount of pabulum to the roots of the plants.

Thick and Thin Sowing. — Uncertainty still exists in the minds of farmers whether thick or thin, drill or broadcast, sowing of oats is the better mode. Numerous experiments have been made on both these points in different parts of the country. The results generally have favoured thin or medium rather than thick sowing, 3½ to 4½ bushels of oats per imperial acre usually giving the best returns on good land and with good seed. As a rule, drill-sowing has been found to be the most economical method.

Sowing Mixed Varieties.—Experiments have shown that a mixture of varieties of oats sown together may produce a heavier crop than when sown singly. For example: J. Finnie of Swanston obtained, when sown singly, from potato oats 74 bushels, Hopetoun 65, early Angus 73, Sandy 56 to 61; whereas, when mixed, these results were obtained: Hopetoun 5 parts, and Kildrummie 1 part, produced 85 bushels; Hopetoun and Sandy, 80; Hopetoun and early Angus, 86; potato and early Angus, 66; and potato and Sandy, 66 bushels. It thus appears that potato oats alone produced 8 bushels more than when sown with either early Angus or Sandy oats; that Hopetoun, with Kildrummie, produced 20 bushels more than when alone, with Sandy 15 more, and with early Angus 11 more.

In these trials an average of 13 bushels more per acre was obtained by mixing seeds of oats of different varieties than when sown singly, and that from a space of ground which took 6 bushels of seed. Still, results of similar trials in other cases have been less favourable to the mixing of varieties.

It must be borne in mind that, in mixing varieties of oats, the varieties to be mixed should come to maturity at the same time.

Oats and Barley Mixed.—Another occasional practice in the north of Scotland is to sow a mixture of barley and oats in the proportion of 4 bushels of oats to 1 bushel of barley. Good results ensue, especially on land where oats, after brairding, become thin or die out. The gross produce is greatly increased, and an excellent food for horses and cattle is obtained.

It is more than probable that the greater produce which is thus obtained from a mixture of oats and barley than from either alone, is that oats and barley search for their food in different layers of the soil—oats penetrating to a considerable depth, whilst barley confines its search mainly to the upper portion of the soil.

Manuring for Oats.

In manurial requirements oats are not much different from barley. They abstract a little more nitrogen and potash, and about the same quantity of phosphoric acid. Oats require more moisture than either wheat or barley, and delight in soils enriched by decayed vegetable matter. Thus oats give large yields on land which has been for a considerable time under grass.

Superphosphate of lime and nitrate of soda applied as a top-dressing give good results when the land requires manuring. The nitrate is specially useful when a bulky crop of straw is desired. Common dressings consist of from ½ to 1 cwt. of nitrate of soda, and from 1 to 2 cwt. of superphosphate. On light land a little potash is sometimes applied with advantage.

But the practice of top-dressing oats is not general. The oat crop, indeed, receives less manure in direct applications than any of the other ordinary farm crops — that is, when the oats follow either grass or roots. Of course, when the oats follow another corn crop some dressing is considered necessary.

Welsh Trials in Manuring Oats.—Trials conducted by the University College of North Wales at Aberystwyth showed that while it is the usual practice to grow the oat crop without the aid of any artificial manures, the application of dressings of complete manures proved highly remunerative, the dressing used consisting of 1 1/7 cwt. nitrate of soda, 2⅔ cwt. superphosphate, and 1½ cwt. kainit per acre. An increase of 20 per cent in this dressing gave only a very slight gain in the crop. A reduction of the dressing by 20 per cent lessened the crop by only a bushel per acre.

Summer Culture of Oats.

The weeding of oats is not often practised when the seed has been sown broadcast, except to remove docks or thistles. When the thistle flourishes amongst corn, it is extremely troublesome to reapers at harvest. This plant should not be cut down till it has attained 9 inches in height, otherwise it will spring from the root, and require another weeding; and by the time it has attained 9 or 10 inches, the oats will be about 1 foot high. In weeding oats in broadcast, the field-workers may be arranged in the manner described for wheat.

Charlock is also a troublesome weed amongst oats. It may be removed as described in the case of barley (p. 135).

A light top-dressing of from 1 to 1½ cwt. nitrate of soda and 2 cwt. superphosphate per acre, is sometimes given to the oat crop early in May.

Oats are as little affected by weather in the flowering season as is barley. Both are in flower about the same time, and the weather must be stormy for successive days to injure either.

Influence of Season and Soil on varieties of Oats.

In connection with the West of Scotland Agricultural College an extensive series of trials were conducted on the growth of different varieties of oats on a large number of farms in the five years 1902-1906. Numerous varieties were tried, but three varieties were taken as standards, the old Scottish Sandy and Potato oats, which have been grown extensively in Scotland for over a century, and the Banner oat, which was introduced from Canada in 1899, and is now largely grown in both England and Scotland. The Banner is known as a grain-rather than a straw-producing type; the Potato as a combined grain and straw producer; and the Sandy as a straw-producing variety.

For the five years these three typical varieties gave the following average yields per acre:—

	Dressed Grain, Bushels of 40 lb.	Light Grain. lb.	Straw. cwt.
Banner	66	225	37
Potato	57	219	41
Sandy	53	262	45

In reporting on the results of these trials for the five years, Principal Wright drew the following conclusions:—

1. That the yield of all varieties of oats varies greatly, according to the character of the season.

2. That the variation in the West of Scotland is less in the case of the acclimatised straw-producing varieties like the Sandy than in the case of new and imported grain-producing varieties like the Banner.

3. That seasons of low temperature, and especially late, cold, and wet spring and early summer weather, are very prejudicial to the yield of the oat crop, and that in such seasons the grain-producing varieties are liable to suffer special damage when grown on cold and unsuitable soils.

4. That, on suitable soils and in suitable districts, the grain-producing varieties of oats like the Banner, on the average of years, give larger and more profitable crops than the older Scottish varieties either of the Potato or of the Sandy type.

5. That, in favourable seasons and on suitable soils, the grain-producing varieties like the Banner will give much larger and more profitable crops than the Scottish varieties.

6. That the grain-producing varieties like the Banner are more liable to be seriously damaged or destroyed by grub than the common Scottish varieties, and that, if grown on land ploughed out of lea, special precautions should be taken to prevent a grub attack, or to assist the oat to resist it.

7. That the grain-producing varieties of oats are best adapted for cultivation either as a second corn crop or after a root crop, and that they should only be grown after lea on friable and open soils, or on land in high condition or liberally manured.

8. That the grain-producing varieties are not adapted for growth on cold or wet clays or mosses, or on poor, exposed, unproductive land, or on tough old lea land, and that on such soils, on the average of years, better crops will be got from the Sandy and similar varieties of the straw-producing type.

9. That the grain-producing varieties are best adapted for growth on good

soils or on soils well drained and in high condition, and in situations not too much exposed to cold north and east winds.

New and Old Varieties of Oats Compared.

In the years 1903-7 a large number of field trials with different varieties of oats were carried out by the Aberdeen and North of Scotland College of Agriculture.

In an extensive series of trials with the new varieties of oats in comparison with the sorts which have been long in use in Scotland, the results generally were strongly in favour of the former, except that in wet years the old varieties gave the better yields of straw.

From these trials it would seem that on the better class of soil, and in a climate not too late, Banner, Siberian, Thousand Dollar, Mounted Police, and Abundance are likely to prove more profitable than other strains. Abundance is the earliest, but the other three are quite as early as Potato or Hamilton. For very early districts the Wide Awake is a most prolific oat, and equal or superior to the Banner, but much later. The earliest oat yet experimented with is the Daubeney of Canadian origin. This variety is two or three weeks earlier than Sandy, but at present decidedly less prolific.

Cross-bred oats are not recommended for the North of Scotland, except for very good land in a good climate. There seems to be some foundation for the belief that they degenerate rapidly, and require to be constantly renewed by supplies from the breeder. Abundance seems to be an exception to this rule.

The Milling Properties of Oats.

In connection with the Aberdeen and North of Scotland College of Agriculture, numerous trials have been conducted on the milling properties of oats. With the object of discovering what foundation exists for the general prejudice entertained by millers against the new varieties of large-grained thick-skinned oats, over eighty milling tests with different varieties of oats from different classes of soils have been made. In 1904 a milling test was undertaken at five places.

The outstanding feature of the experiment is the comparatively poor result from Potato and Scots Birlie,—comparatively poor in the sense that the reputation of these oats for milling does not seem to be justified by the figures. The average produce from 168 lb. of oats is 100 lb. of meal, and the local kinds are capable of producing as much but apparently not more, whereas general opinion would credit them with a larger out-turn. The table below shows the meal from each of the five centres and the average from all, and there is nothing to indicate the superiority of Potato or Scots Birlie:—

MEAL OBTAINED FROM 168 LB. GRAIN.

	Echt.	Denwell.	Cairnbulg.	Tipperty.	Hare-stone.	Average.	
	lb.	lb.	lb.	lb.	lb.	lb.	Per cent.
Siberian	101	101	103½	104½	101	102.2	60.7
Thousand dollar	100	100	100	105½	101	101.3	60.3
Waverley	101	101	99	103	102	101.2	60.2
Scots Birlie	98	104½	100½	105	96	100.8	60.0
Wide Awake	96	104	103	98	103	100.8	60.0
Newmarket	101	100	101	100	101	100.6	59.8
Banner	100½	101	99½	98	103	100.4	59.7
Potato	95	104	102	105	95	100.2	59.6

In 1906 a more complete test under the most careful supervision did nothing to enhance the reputation of Potato. Seed of Thousand Dollar, Potato, and Banner was obtained from one farm in Inverness-shire and sown at Berrymoss in Aberdeenshire, and Cowfords in Morayshire. Four quarters of dressed

grain of each variety were ground at Berrymoss and five quarters at Cowfords. The results obtained were as follows:—

Variety.	Percentage of water.	Percentage of husk in		Percentage of dust in		Percentage of meal-seeds in		Percentage of oatmeal in	
		Raw grain.	Dried grain.	Raw grain.	Dried grain.	Raw grain.	Dried grain.	Raw grain.	Dried grain.
Berrymoss—									
Thousand dollar . .	18.82	13.61	16.68	4.98	6.05	3.05	3.76	59.52	73.33
Potato	19.50	14.06	17.47	5.57	6.93	2.82	3.51	58.03	72.09
Banner . . .	18.53	14.80	17.99	5.73	7.03	3.27	4.02	57.81	70.96
Cowfords—									
Thousand dollar . .	10.71	13.69	15.33	4.17	4.66	2.95	3.33	68.51	76.66
Potato	11.90	12.79	14.53	3.87	4.39	3.27	3.71	68.21	77.36
Banner . . .	13.69	13.69	15.80	4.76	5.53	4.17	4.83	63.69	73.79

The weight of evidence from these trials goes to show that the milling properties of the Potato are exaggerated in popular estimation, and that several cross-bred and foreign oats are quite equal, if not superior, to the common strains. When the total quantity of meal produced per acre is considered, the comparison is entirely favourable to the newer varieties.

Effect of Soil on Milling Property.—It is well known that millers have a preference for oats from certain soils, and even from particular farms. Two of the foregoing trials throw some light on this preference. Tipperty is on a stiff boulder clay not far from the sea; Echt is on a light gravelly drift soil about twelve miles inland. The yields of meal from these two centres were as follows:—

	Boulder clay. Per cent of meal.	Gravelly drift. Per cent of meal.
Siberian . . .	62.2	60.1
Thousand Dollar .	62.8	59.5
Waverley . . .	61.3	60.1
Scots Birlie . .	62.5	58.3
Wide Awake . .	58.3	57.1
Potato . . .	62.5	56.5
Newmarket . .	59.5	60.1
Banner . . .	58.3	59.8
Average . .	60.9	58.9

Except Newmarket and Banner all the varieties gave more meal on the stronger soil.

SOWING RYE.

Rye is sown for its grain and straw, and also for forage. Where land is too light and sandy for wheat, after any green crop, rye may be sown in autumn; and its culture is similar to that for wheat. One ploughing suffices, and two turns of the harrows finishes the surface, 2½ bushels of seed being sown per acre.

Rye will thrive in drifting sand, and will endure the hardest frost. It grows rapidly, and in Germany, where it is largely grown for bread, it is often harvested before the end of June.

As an ordinary cereal crop, however, it is now grown in this country only to a very limited extent. Rye is further dealt with in the section on "Forage Crops."

ROLLING LAND.

The common land-roller is an implement of simple construction, the acting part of it being a cylinder of wood, of stone, or of metal. Simple, however, as this implement appears, there is hardly an article of the farm in which the farmer is more liable to fall into error in its selection.

From the nature of its action, and its intended effects on the soil, there are two elements that should be particularly kept in view—*weight* and *diameter* of the

cylinder. By the weight alone can the desired effects be produced in the highest degree, but these will be always modified by the diameter. Thus, a cylinder of any given weight will produce a greater pulverising effect if its diameter is 1 foot, than the same weight would produce if the diameter were 2 feet; but then the one of lesser diameter will be much heavier to draw, hence it becomes necessary to choose a mean of those opposing principles. In doing this, the material of the cylinder comes to be considered.

Wood, which is still employed for the making of land-rollers, may be considered as least adapted of all materials for the purpose. Its deficiency of weight and liability to decay render it objectionable. *Stone*, though not deficient in weight, possesses the one marked disadvantage of liability to fracture. This of itself is sufficient to place stone rollers in a doubtful position as to fitness. *Iron and steel* are undoubtedly the most appropriate of all materials for this purpose.

Diameter and Weight of Rollers.—There has been much discussion from time to time as to the most advantageous diameter for a land-roller. The preponderance of practical evidence is to the effect that a diameter of 2 to 2½ feet is, under every circumstance, the one that will produce the best effects with a minimum of labour from the animals of draught. In many cases, however, rollers of less as well as of greater diameter are in use. The weight is, of course, proportioned to the force usually

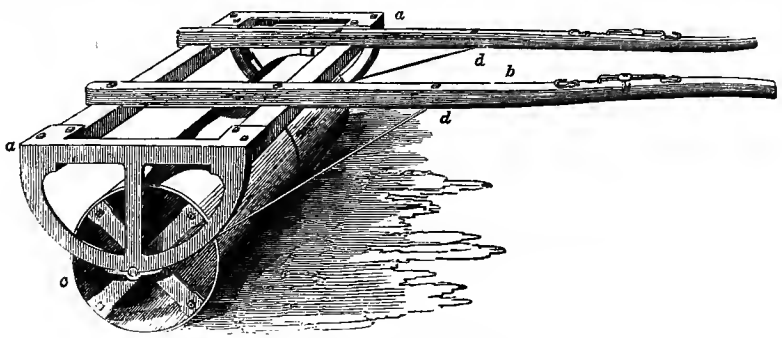


Fig. 429.—*Cast-iron land-roller.*

a a Carriage-frame. *b* Horse-shafts. *c* Cylinder. *d d* Iron stays.

applied, generally 1 but often 2 horses. The weight of roller, including the frame corresponding to this, is from 10 to 15 cwt. But some think it better that the roller itself should be rather under these weights, and that the carriage be fitted up with a box in which a loading of stones can be stowed, to bring the machine up to any desired weight. Such a box is, besides, useful in affording the means of carrying off from the surface of the ground any large stones that may have been brought to the surface by the previous operations.

Divided Roller.—In a large and heavy roller, in one entire cylinder, the inconvenience of turning at the headlands is very considerable, and has given rise to the improvement of having the cylinder in two lengths. This, with a properly constructed carriage, produces a very convenient form of land-roller. Fig. 429 is a perspective of the land-roller constructed on the foregoing principles, with the carriage-frame crossed by the horse-shafts. The cylinder is in 2 lengths of 3 feet to 3 feet 3 inches each, and 2 feet in diameter; the thickness of the metal is according to the weight required. The axle, in consequence of the cylinder being in two lengths, requires to be of considerable strength, and of malleable iron; upon this the two sections of the cylinder revolve freely, and the extremities of the axle are supported in bushes in the semi-circular end-frames. Two iron stay-rods pass from the end-frames to the shafts as an additional support to the shafts.

Excellent rollers are now made of steel sheets fixed on wrought- or cast-iron ends.

Water-ballast Roller.—A very convenient form of roller, made by Barford & Perkins, Peterborough, is represented in fig. 430. It is made in two enclosed cylinders of wrought iron, formed so that by filling or partially filling the cylinders with water, the weight of the roller may be varied as desired. These water-ballast rollers are made of many sizes for field and garden work, and are exceedingly convenient to work and move about. A water-ballast roller, 2 feet in diameter, weighs about 11 cwt. when empty, and 22 cwt. when quite full of water.

Process of Rolling.—The rolling is always effected across the line of ridges. Otherwise the open furrows would not receive any benefit from it. Although the dividing of the cylinder into two parts facilitates the turning of the implement, it is not advisable to attempt to turn the roller sharply round, as part of the ground turned upon may be rubbed hard by the cylinders, with the result that young plants may be injured or killed.

The rolling is sometimes executed in feers of 30 yards in width, *hieing* the horses one-half of the feering and *hupping* them in the other half. This, however, is unnecessary with care at the turning. When the ploughman becomes fatigued with walking, it may be allowable for him to sit on the front of the framing, where a space is either boarded or wrought with hard-twined straw-rope, as a seat from whence to drive the horses with double reins and whip. With this indulgence, an old ploughman, employed only in ploughing, could take the rolling when urgent work was employing the stronger horses in the cart.

Speed in Rolling.—Were a 6-feet roller to proceed uninterruptedly for ten hours, at the rate of 2½ miles per hour, it would roll about 18 acres; but what with the time spent in the turning and the markings-off of feerings, 10 to 12 acres a-day may be considered a good day's work. When the weather is favourable, and a large extent of ground has to be rolled, it is a good plan to work the roller from dawn to nightfall, each horse or pair, as the case may be, working 4 hours at a time. In this way, 16 hours' constant rolling, from 4 in the morning till 8 at night, may be obtained in the course of 24 hours, and from 25 to 30 acres rolled with one roller.

Time for Rolling.—The usual time for rolling is immediately after the seed has been sown. But the condition of the land as to moisture must be considered.

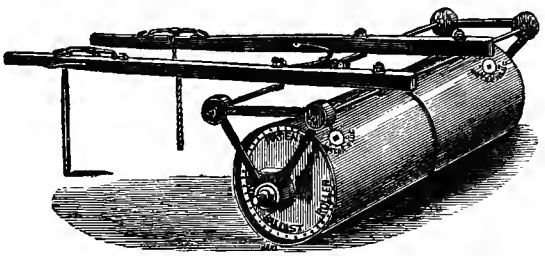


Fig. 430.—*Water-ballast roller.*

The young braird on strong land is much retarded when the earth becomes encrusted by rain after rolling, so that such land in wet districts is in rainy seasons not rolled until the end of spring, when the plant has made some progress, and the weather continues dry. Light friable dry land should be rolled immediately after the seed is sown and harrowed, if there is time to do it. But the rolling of one field should not be allowed to cause delay in the sowing of others in dry weather. There will be plenty of time to roll the ground after the oat seed and other urgent operations at this season are finished.

On the other hand, the rolling is most effective in securing smoothness in the surface immediately after harrowing has been completed. And for the sake of the reaping-machine a smooth surface is of much importance.

In preparing land for grass and clover seeds the roller is not, as a rule, used so much as it should be. An even, firm seed-bed is of the utmost importance for these tiny seeds, just as it is for the seeds of the turnip crops.

GENERAL PRINCIPLES OF CORN CULTURE.

The sowing of the chief cereal crops has thus been dealt with. Much more might have been said on the subject, but there seems to be little necessity for describing at great length operations which are so simple as the cultivation of corn. Of all important work upon the farm this is, perhaps, the most simple and the most uniform in the methods of procedure.

The simplicity and the universality of the general principles of *corn cultivation* are well shown by Professor Wrightson in the following admirable epitome:—

"No business pursuit is easier than corn cultivation, and this is why we have such millions of bushels of corn thrown in upon us. It is a cheap cultivation. All we have to do is to plough the land, throw on the seed, and scratch it in. Of course we must do this at the right time of the year, and in the proper manner. When we take wheat or barley, or oats [to be sown in the autumn or winter], after a root cropped on the land, a very general method of cultivation is as follows: We first plough about 4 inches deep, then broadcast the seed upon the newly turned up fallow, and put the harrows on and give it a really good harrowing, so as to break the compact furrow and cover the seed thoroughly—that is all. Protect it from the ravages of the birds, and in the spring of the year roll and harrow it, and that is pretty much the cultivation of corn after roots. A great deal of corn is taken after grass and clover crops; and the cultivation of either oats or wheat, or barley after lea, is much the same thing. We plough and press, and often sow the seed upon the pressed furrow and harrow it in.

"Again, in other cases we plough, press, or heavily roll, harrow repeatedly, and drill. That again is the whole of the cultivation. Corn crops sometimes follow peas or beans, in which case the plan would be to dung the surface, and then proceed as before, ploughing in the dung, and either broadcasting or else producing a proper seed-bed with the use of the harrow, and drilling in the corn."[1]

[1] *Prin. of Ag. Practice*, 136.

Insect attacks upon corn and other crops are dealt with in a special chapter.

CROSS-PLOUGHING LAND.

The first preparation for cereal seed after turnips is ploughing the land across at right angles to the existing ridges. The surface of the ground where sheep consume turnips is left in a smooth state, trampled firm by the sheep, presenting no clods of earth but perhaps numbers of small round stones, which should be removed with carts before the cross-ploughing is begun. The small stones are useful for drains, or to repair farm roads, and the larger stones for dykes.

A plough then feers the ground for cross-ploughing. The reason that land is cross-ploughed for barley, and not for spring wheat, after turnips eaten off by sheep, is, that wheat thrives best when the soil is firm and not too much pulverised—whereas the land cannot be in too fine a condition for barley. Moreover, if the turnip-land were not cross-ploughed after the sheep left it, their manure would not be sufficiently intermixed with the soil, and in consequence the barley would grow irregularly in small rows, corresponding to the drills that had been manured for the turnip crop.

Harrowing before Cross-ploughing.—The portion of the stubble-land first to be cross-ploughed is for beans. Every winter-ploughed field for cross-ploughing in spring is freed from large clods by *harrowing*. The winter's frost may have reduced the clods of the most obdurate clay soil, and the mould-board of the plough may thus be able to pulverise them fine enough, while the lighter soils may have no clods upon them. In this case it would seem loss of time to harrow the ground before cross-ploughing, and some farmers do not then use the harrow; yet, in the majority of cases, the harrowing will be found beneficial. One cannot be sure that, in the strongest soil, all the clods have been reduced to the heart by frost; and should any be buried by the cross-furrow while still hard, they will not afterwards be so easily pulverised amongst the soft soil as when exposed upon the harder surface of the winter-furrow. Then in the lightest soils, the harrows not only make a smoother

surface, but intermix the surface-dry, frost-pulverised soil with the moister and firmer soil below, as far as the tines of the harrows can reach.

There is not much time lost in harrowing before cross-ploughing; and although it should require a double tine to pulverise the clods, or equalise the texture of the ground, it should be *across* instead of along the ridges, to fill up the open furrows with soil, whether the land had been previously ploughed with gore-furrows or not.

If time presses, the feerings for cross-ploughings may be commenced by one plough almost immediately after the harrows have started; and if the harrows cannot get away before the plough, the plough can take a bout or two round the first feering till the harrows have reached the second feering; or, still better, the harrows can go along each feering, preparing the ground for the plough, and then return and finish the harrowing between the feerings.

Thus, in fig. 431, after the first feering *e f* across the ridges has been ploughed, the plough can either take a bout or two round *e f*, till the harrows have passed the next feering *g h*, or the harrows can

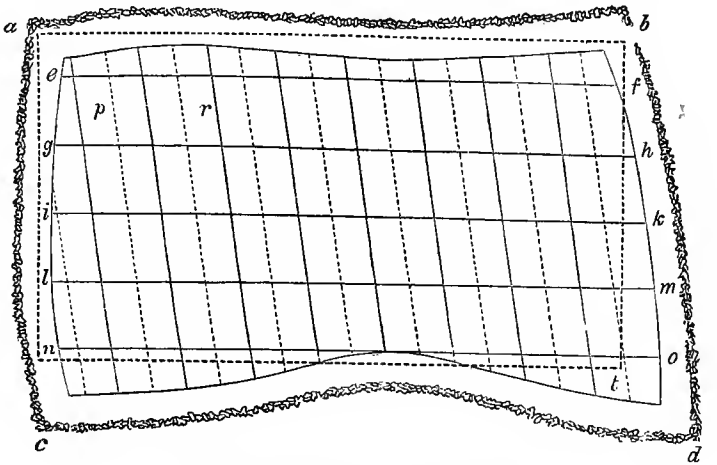


Fig. 431.—*Field feered for cross-ploughing.*

go along the line of each feering, at 30 yards' distance, first *e f*, then *g h*, then *i k*, and so along *l m* and *n o* in succession, and prepare the ground for feering, and then return and harrow out the ground between *e* and *g*, *g* and *i*, *i* and *l*, and *l* and *n*. In this way the harrowing and feerings, and ploughing the feerings, may go on at the same time.

System of Cross-ploughing.—But if time is not urgent, the systematic way is to feer the field across, at 30 yards' distance, from *e* to *n*, across the whole field, and the ploughs take up the feerings in succession. To illustrate this more fully, suppose that all or as much of the field to be cross-ploughed has been harrowed as will give room to a single plough to make the feerings without interruption. In choosing the side of the field at which the feerings should commence, it is a good rule to begin at the side farthest from the gate and approach gradually towards it, because then the ends of the finished feerings will not be passed, and the trampling of the ploughed land be avoided. The convenience of this rule is felt not in cross-ploughing only, but in prosecuting every kind of field-work; for besides avoiding damage to finished work, it is gratifying to the mind that, as work proceeds, the approach is nearer home; while it conveys the idea of a well-laid plan to have the operations of a field commenced at the farthest end and finished at the gate, where all the implements meet, ready to be conveyed to another field. The gate is like home, and in most cases it is placed on the side or corner of a field nearest the steading.

Ploughing Ridges and Feerings.—Some farmers neglect the head-ridge in the cross-ploughing, and measure the feering from the open furrow which divides the head-ridge and the ends of the ridges. The head-ridges ought to be ploughed at this time along with the rest of the field, for, if neglected now, the busy seasons of spring and early summer will draw away attention from them, till, what with trampling in working the green crop and the drought of the weather, they will become too hard to plough, and will lose the ameliorating effects of sun and air in the best part of the year.

In cross-ploughing the ridges of the field, the head-ridges must be ploughed in length, for they can never be *cross*-ploughed.

Depth of Cross-furrow.—The depth of the cross-furrow varies with the character of the soil. It is often, in good soil, deeper than the winter-furrow. The deepness is easily effected by the plough passing under the winter-furrow and raising a portion of the fresh soil below it. If the under soil is suitable, the 2 inches of fresh subsoil mix well with the thicker winter-furrow.

Cross-ploughing the first furrow in spring is unsteady work for the ploughmen, the open furrows presenting little resistance to the plough compared with the crown of the ridge.

The depth of the cross-furrow may vary from 8 to 12 inches, 10 inches being quite common.

Grubbers or cultivators are now extensively employed in spring tillage. To these operations fuller reference will be found in the chapter dealing with sowing turnips.

BEANS AND PEAS.

Beans.

Beans are classed with a very different tribe of plants from the cereals which we have been considering. They belong to the natural order *Leguminosæ*, because they bear their fruit in legumes or pods. Their ordinary systematic name is *Faba vulgaris;* but the bean is also known as *Vicia Faba.*

The common bean is divided into two classes, according to the mode of culture to which it is subjected—that is, the field or the garden. Those cultivated in the field are called *Faba vulgaris arvensis*, or, as Loudon calls them, *Faba vulgaris equina*, because they are cultivated chiefly for the use of horses, and are usually termed horse-beans. Some farmers attempt to raise a few varieties of the garden-bean in the field, but without success. All beans have butterfly or papilionaceous flowers.

Field-bean.—Lawson has described 8 varieties of the field-bean. The variety in common field-culture is thus well described by him: "In length the seed is from a half to five-eighths of an inch, by three-eighths in breadth, generally slightly or rather irregularly compressed and wrinkled on the sides, and frequently a little hollowed or flattened at the end; of a whitish or light-brown colour, occasionally interspersed with darker blotches, particularly towards the extremities; colour of the eye black; straw from 3 to 5 feet in length. There is, perhaps, no other grain over the shape and colour of which the climate, soil, and culture exert so much influence as the bean. Thus, in a dry warm summer and harvest, the sample is always more plump and white in colour than in a wet and cold season; and these more so in a strong rich soil than in a light, and more so in a drilled crop than in one sown broadcast."[1]

Fig. 432 represents the horse-bean of its natural size.

Leguminous Plants.—"The leguminous order," observes Lindley, "is not only among the most extensive that are known, but also one of the most important to man, whether we consider the beauty of the numerous species, which are amongst the gayest-coloured and

[1] Lawson's *Agric. Man.*, 62.

most graceful plants of any region, or their applicability to a thousand useful purposes.

"The cercis, which renders the gardens of Turkey resplendent with its myriads of purple flowers; the acacia, not less valued for airy foliage and elegant blossoms than for its hard and durable wood; the braziletto, logwood, and rosewoods of commerce; the laburnum; the classical cytisus; the furze and the broom, both the pride of the otherwise dreary heaths of Europe; the bean, the pea, the vetch, the clover, the trefoil, the lucerne, all staple articles of culture by the farmer, are so many leguminous species. The gums, Arabic and Senegal, kino, senna, tragacanth, and various other drugs, not to mention indigo, the most useful of all dyes, are products of other species; and these may be taken as a general indication of the purposes to which leguminous plants may be applied. There is this, however, to be borne in mind, in regarding the qualities of the order in a general point of view—viz., that, upon the whole, it must be considered poisonous, and that those species which are used for food by man and animals are exceptions to the general rule; the deleterious juices of the order not being in such instances sufficiently concentrated to prove injurious, and being in fact replaced, to a considerable extent, by either sugar or starch."[1]

Fig. 432.—*Horse-beans.*

Beans containing Poison.—In various cases in Great Britain sudden deaths occurring amongst cows have been attributed to beans included in the food. Investigations conducted by Mr Hendrick, Chemist to the Highland and Agricultural Society of Scotland, showed that prussic acid existed in dangerous quantities in samples of beans imported from Java, and that this virulent poison was also found in Burma beans, though in smaller quantities. In purchasing imported beans, farmers should therefore exercise great care, requiring the sellers to guarantee that the beans are free from poison. It has been found that boiling twice over renders the poisonous beans harmless.

Yield and Weight of Beans.—The produce of the bean crop varies from 20 to 40 bushels per imperial acre, the prolificness of the crop palpably depending on the nature of the season. The average weight may be stated at 66 lb. per bushel. It requires only 5 beans to weigh 1 drachm, so that a bushel contains only 42,240 beans. Beans have been known to yield 2 tons of straw or haulm per acre.[2] A crop of 40 bushels, at 66 lb. per bushel, gives 1 ton 3 cwt. 64 lb. per acre.

Consumption of Beans.—Beans are given to the horse, whole, boiled, raw, or bruised. They are given to cattle in the state of meal, but can be ground into fine flour, which is used at times to adulterate the flour of wheat. Its presence is easily detected by the peculiar smell arising from the flour on warm water being poured upon it.

"There are several varieties of the bean in use as horse-corn, but I do not know that one is better than another. The small plump bean is preferred to the large shrivelled kind. Whichever be used, the bean should be old, sweet, and sound; not mouldy, nor eaten by insects. New beans are indigestible and flatulent; they produce colic and founder very readily. They should be at least a year old."[3]

Peas.

The *pea* occupies a similar position to the bean in both the natural and artificial systems of botany. The plant is cultivated both in the field and in the garden, and in the latter place to great extent and variety. The *natural* distinction betwixt the field- and the garden-pea is founded on the flower, the field-pea always having a red-coloured and the garden almost always a white one; at least, the exceptions to this mark of distinction are few.

The botanical name of the pea is *Pisum sativum*, the cultivated pea; and those varieties cultivated in the field are called in addition *arvense*, and those in the gar-

[1] Lindley's *Veget. King.*, 546, 547.

[2] *Brit. Husb.*, ii. 215.

[3] Stewart's *Stab. Eco.*, 205, 206.

den *hortense*. The name is said to have been given to it by the Greeks, from a town called Pisa, in Elis, in the neighbourhood of which this pulse was cultivated to a great extent: Paxton derives the name from the Celtic word *pis*, the pea, whence the Latin *pisum*.[1]

Lawson has described 9 varieties of the field-pea. Of these, a late and an early variety are cultivated. The late kind, called the *common grey field-pea* or *cold-seed*, is suited for strong land in low situations; and the early, the *partridge*, *grey maple*, or *Marlborough pea*, adapted to light soils and late situations, is superseding the old grey Hastings, or *hot-seed* pea.

The grey pea is described as having "its pod semicylindrical, long, and well filled, often containing from 6 to 8 peas. The partridge pea has its "pods broad, and occasionally in pairs, containing from 5 to 7 peas of a medium size, roundish, and yellowish-brown speckled, with light-coloured eyes. The ripe straw is thick and soft-like, leaves large and broad, and average height 4 feet."[2]

Fig. 433.—*Partridge field-pea.*

Fig. 433 is the partridge field-pea of the natural size.

Produce of Peas.—The produce of the pea crop varies greatly according to the season. In warm weather, with occasional showers, the crop may amount to 48 bushels, and in cold and wet it may not reach 12 bushels the acre. The grain weighs 64 lb. the bushel, and affords 13 grains to 1 drachm; consequently a bushel contains 106,496 peas.

Consumption of Peas.—The pea was formerly much cultivated in this country in the field, and even used as food, both in broth and in bread, *pease bannocks* having been a favourite food of the labouring class; but, since the extended culture of the potato, its general use has greatly diminished. It is now chiefly given to horses, and also split for domestic purposes, for making pea-soup—a favourite dish with families in winter. Its flour is used to adulterate that of the wheat, and is easily detected by the peculiar smell which it gives out with hot water. Peasemeal in brose is administered in some cases of dyspepsia. Pea-pudding is eaten as an excellent accompaniment to pickled pork. Pigeons are excessively fond of the pea, and it has been alleged that they can devour their own weight of them every day.

[1] Paxton's *Bot. Dict.*, art. Pisum.
[2] Lawson's *Agric. Man.*, 70.

Bean- and Pea-straw.

Bean- and pea-straw, or haulm, are difficult in some seasons to preserve, but, when properly preserved, no kind of straw is so greatly relished as fodder by every kind of stock.

According to Sprengel, the ash of bean- and pea-straw contains the following ingredients:—

	Field-bean.	Field-pea.
Potash	53.08	4.73
Soda	1.60	...
Lime	19.99	54.91
Magnesia	6.69	6.88
Alumina	0.32	1.21
Oxide of iron	0.22	0.40
Oxide of manganese	0.16	0.15
Phosphoric acid	7.24	4.83
Sulphuric acid	1.09	6.77
Chlorine	2.56	0.09
Silica	7.05	20.03
	100.00	100.00

Percentage of ash, from 4½ to 6.

Young cattle are very fond of bean-*chaff*, and, with turnips, thrive well upon it. Cows also relish it much.

SOWING BEANS.

On suitable soil the bean crop is usually a profitable one. As the bean takes about 7 months to come to maturity, the crop should be sown as early in spring as possible. It should be sown in February if the weather and the condition of the land permit; in no case later than March. A very favourable season may hasten the plant through its courses of vegetation in a shorter time; but a very unfavourable season will so retard it as almost to prevent the formation of the seed.

In Scotland the bean is not a reliable crop. It was never cultivated extensively there, and in recent years has lost

ground slightly. Strong land is best suited for beans, which still hold an important place on good carse farms. The land must be in good heart, and is generally well manured with dung in the previous autumn or winter. Beans are sown on the flat surface, or in rows from 15 to 20 inches apart, or in raised drills from 25 to 30 inches wide. The bean crop occupies varying positions in the rotation. It may come in between two cereal crops, between two crops of wheat, between oats and wheat, or between wheat and barley.

The bean crop is valuable both for its straw and grain. Though the crop fail in seed, it seldom fails to produce good fodder provided it can be well secured. A dry season stints the growth of the haulm, but produces beans of fine quality; and a wet season prevents the growth of the bean, but affords a bulky crop of fodder.

The culture for beans is not dependent so much on the soil as on the peculiar growth of the plant. Bearing fruit-pods on its stem near the ground as well as near the top, it should have both light and air; and its leaves being at the top, and its stem comparatively bare, weeds find room to grow. The plant should therefore be wide asunder in the row and between the rows, so that the crop may become luxuriant and the land cleaned.

Beans were long wont to be sown broadcast, and are so sown still in some cases. It is not a good plan, however, for it has a great tendency to leave the land full of weeds.

Varieties of Beans.—Several varieties are in cultivation. Those most largely sown are the common Scotch or horse-bean, and the common tick-bean. The former is the best suited for northern districts, and under favourable circumstances grows to a height of 4 or 5 feet, weighing from 62 to 65 lb. per bushel. The seed is large, flat, of a dingy whitish colour, with a black eye, and irregularly wrinkled on the sides. The tick-bean, which is shorter in the straw, and generally more prolific, is the variety most largely cultivated in England. The seed is smaller, plumper, a pound or two heavier per bushel than the seed of the horse-bean. Amongst the other best-known varieties are the Russian or winter bean, the Mazagan, and the Heligoland bean.

Quantity of Seed. — From two to four bushels per acre are the most general quantities. In the north it is more frequently four, sometimes even five bushels. The seed is sown by machines of various patterns—barrow-shaped appliances, worked by hand or horse-power, and sowing usually one or three drills or rows at a time.

Manure for Beans.—Land intended for beans is usually well dunged in the autumn, or early in winter, with perhaps from 8 to 12 tons of farmyard dung, spread just before the land is ploughed. The dung will be all the better for this purpose if it is tolerably fresh, and it should be spread evenly on the land. In other cases, the dung is spread early in spring on the flat or in drills, as for turnips. When the dung is to be spread in drills, these are opened a little deeper than if the land were simply drilled to receive the seed.

Formerly it was thought that beans could not be grown satisfactorily without farmyard dung, but, as shown clearly by the Highland and Agricultural Society's experiments, that idea was not well founded. The artificial manures which gave the best results in these experiments are described at pp. 38, 39. Potash is the dominant ingredient. It is seen that, unaccompanied by potash, neither phosphates nor nitrate is of much use to the bean, whether applied separately or together; but the addition of potash to either or both at once enormously increases the crop. The artificial manures were applied in March, three days before the seed was drilled in with the three-drill bean-barrow.

Beans and Nitrogenous Manure.—Seeing that a leguminous crop such as beans contains a great deal more nitrogen than cereal crops, it might be expected that nitrogenous manures would exercise a more beneficial effect upon beans than upon cereals. It has been found, however, that such is not the case. At Rothamsted extensive experiments have been carried out in the manuring of beans and other leguminous crops, but, curiously enough, the results have not been so clear or instructive as those obtained from the

manuring experiments with most other crops. Sir J. B. Lawes says:—

"The general result of the experiments with beans has been, that mineral constituents used as manure (more particularly potash) increased the produce very much during the early years; and to a certain extent afterwards, whenever the season was favourable for the crop. Ammonia-salts, on the other hand, produced very little effect, notwithstanding that a leguminous crop contains two, three, or more times as much nitrogen as a cereal one grown under similar conditions as to soil, &c. Nitrate of soda has, however, produced more marked effects. But when the same description of leguminous crop is grown too frequently on the same land it seems to be peculiarly subject to disease, which no conditions of manuring that we have hitherto tried seem to obviate.

"Experiments with peas were soon abandoned, owing to the difficulty of keeping the land free from weeds, and an alternation of beans and wheat was substituted,—the beans being manured much as in the experiments with the same crop grown continuously.

"In alternating wheat with beans, the remarkable result was obtained, that nearly as much wheat, and nearly as much nitrogen, were yielded in eight crops of wheat in alternation with the highly nitrogenous beans, as in sixteen crops of wheat grown consecutively without manure in another field, and also nearly as much as were obtained in a third field in eight crops alternated with bare fallow."

Ploughing for Beans.—Strong land intended for beans is usually ploughed about the end of autumn or early in winter, so that it may have the benefit of the pulverising influences of winter. If the land is very heavy and liable to hold surface water, it will be useful to plough it in the direction of the greatest inclination or fall, so that there may be no cross-furrows to retain the water. But when the land can be ploughed across the inclination it will be well to do so, and then the drills, if the crop is to be grown in drills, will follow the inclination, thus crossing the autumn furrow.

Spring Tillage for Beans.—The amount and kind of tillage which bean land should receive in spring will depend upon the nature and condition of the land and the character of the season. If the land lying in the winter furrow is tolerably friable, harrowing may be sufficient. As a rule, however, a turn of the grubber or cultivator will be found highly beneficial.

Cultivators and Grubbers.—The improved grubbers or cultivators are excellent implements for pulverising surface-soil. They do their work well, and are very speedy—a consideration of special importance at this time of the year. They are extensively employed in almost all parts of the British Isles where tillage farming is pursued. Cultivators are now designed so that by changing fittings they can perform various tillage operations, thus economising outlay in the cost of implements.

The action of the grubber or cultivator in the soil is to stir it effectually as deep as the tines descend, and at the same time retain the surface-soil in its existing position. This advantage is especially appreciated in early spring, when it is precarious to turn over the soil with the plough, lest by a fresh fall of rain it should become wetter and worse to work than if it had not been ploughed at all. If the land be raw and not very clean, and the weather precarious, the grubber will prepare the soil for harrowing, of which it should receive one double tine along the ridges, the grubbing having been given across them. Should this not be sufficient to reduce the clod, another double tine should be given across the ridges, when the land will be ready for sowing.

If the weather in spring is favourable, and the beans are to be sown broadcast or in rows on the flat, ploughing across the winter furrow is by many considered desirable. The modern grubbers or cultivators, however, do their work so well that the necessity for the plough in spring is much lessened.

In preparing land in spring for beans, care should be taken not to grub or harrow more in one day than can be drilled up or sown on the same or the following. A fall of rain on this prepared ground before it is drilled for the seed would be detrimental to the crop.

Sowing Autumn-manured Beans.

—The process of sowing beans upon land which had been purposely dunged and ploughed in autumn or early winter is thus described by Mr F. Muirhead:—

"We will suppose the time has arrived for sowing the seed. The farmer should previously have had his bean-sowing machine examined, repaired if necessary, and well oiled. He should also have provided the requisite quantity of seed—say 4 bushels of common Scotch beans for every imperial acre; and he had better have an extra bag of beans for every twenty he intends to sow, in case he may need a little more to finish the field than he anticipated.

"He should visit the field a day beforehand, and ascertain the length of the proposed drills, and how many make an imperial acre; and the following table may assist him:—

Inches wide. Drills.	Yards long. Imperial acre.
26	6701
27	6453
28	6222

"The open furrows should be filled in with two or three bouts of a two-horse plough, and the ends or headlands marked off, say, to hold eight drills, which should be ample room to admit of horses and ploughs turning quickly without treading on the newly formed drills. If the land requires a double stroke of heavy harrows before being drilled, as much should be harrowed the afternoon previous to sowing (provided weather is somewhat settled) as to allow the ploughs to get to work *readily* the following morning, or the foreman had better be sent half a day beforehand to do this, and to open, say, ten or twelve drills; and care should be taken, if the field has much inclination from top to bottom, to begin at that side of it which will, in covering up the sown seeds, give the horses the heavy furrow *down* hill. The following morning fully as much seed is taken out to the field as will likely be needed during the forenoon, and the bags should be placed along the top headland, if drills are not too long to admit of the three-drill horse sowing-machine sowing a 'bout' or six drills before it needed to be refilled, care being taken that the seed always covered the pinions for forcing out the beans.

"In placing the bags with the seed, suppose that it takes thirty drills to be an acre imperial, and we wish to sow 18 stones per acre, it will be more convenient to have the beans weighed up to that weight in each bag, and place the bags along the headland, one bag at the last drill of each acre; and in beginning to sow, it will be found of advantage to take out as much extra seed in a bag as cover the pinions of the sowing-machine, so that when the *first* bag is all sown, the person in charge knows at once whether the machine is sowing too quickly or too thinly. Perhaps if the first bag were accurately divided into two, and set down separately, at half an acre for each, the setting of the machine would be the sooner tested. The sowing-machine will now begin and sow the three outside drills, and the ploughs will commence and cover up the seed as they go *down hill*, and open fresh drills at the required width as they return. One sowing-machine will easily keep four or five pairs of horses at work." [1]

Sowing Spring-manured Beans.—When the dung has to be applied to the drills in spring, it is carted to the field, and thrown in graipfuls as the horse moves along the drills, just as in the dunging of roots or potatoes. The graipfuls are then spread evenly along the bottom of the drills, which, having received the seed, are thereupon closed.

If the dung has to be applied in spring, and it is intended to sow the beans *broadcast* or *in rows* on the flat, then the land receives a single or double turn of the harrow, the dung is spread evenly on the surface, and the land ploughed, the seed, perhaps, being dropped by the single bean-barrow into every third furrow. And as the furrows are about 9 inches in breadth, the three furrows will place the rows of beans at 27 inches apart. This ploughing finishes the operation.

When the land is manured in the spring, and the seed sown broadcast, the dung in the same state is spread broadcast upon the surface. The further part of the operation depends on the state of the weather. Should it promise well until the bean-sowing is finished, the dung may be ploughed in, the seed sown

[1] *Farming World Almanac*, 1888.

broadcast upon the ploughed surface, harrowed in with a double tine, and the ridges water-furrowed. Should the weather seem doubtful, a safer plan is to sow the seed broadcast upon the spread dung, and plough in both seed and dung together, and the surface will be secured from danger. In this case the plants will come up in rows of the breadth of the furrow—9 inches apart.

Harrowing Drills.—If it is considered desirable to harrow the drills, this may be done about a fortnight after the sowing, if the surface is at all dry. If the land is wet, the harrowing should be delayed, and the first dry state of the surface taken advantage of. The common harrow is sometimes used to harrow

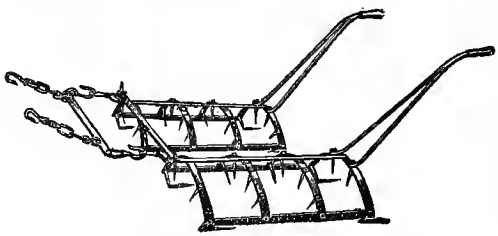


Fig. 434.—*Saddle drill-harrow.*

down drills; but a better implement is the *saddle drill-harrow* (Clay), represented in fig. 434. This harrow is worked in pairs; and, to render it applicable to its purpose, it is made of an arch form, partially embracing the curvature of the drill, and on this account is best fabricated of iron. The pair of harrows are drawn by one horse, walking between the drills. Chain-harrows are also useful for this purpose.

Summer Culture of Beans.

Beans require a good deal of labour and attention in summer.

Horse-hoeing.—As soon as the young plants growing on raised drills have attained 2 or 3 inches in height, the common drill-grubber or scuffler should remove the weeds that have appeared between the drills in the interval of time since the drill-harrowing. The grubbing will also reduce the clods and loosen the soil generally.

Hand-hoeing.—The field-workers follow the scuffler with the hand-hoe, and remove the weeds growing around the plants, and displace clods that are seen to interfere with the plants. The workers should be careful in using the hoe amongst bean plants, which are very tender and easily cut and bruised.

After the plants have risen about 1 foot in height, which they will soon do in good growing weather, the blossom will begin to appear; and its appearance is with many the signal to finish the work amongst the crop. Time may be found to again drill-grub between the drills, and hoe the sides of the drills along the plants; but if not, the double mould-board plough should, as the last operation, set the earth up to the roots of the plants, to give them a firm footing on the top of the drill.

Rows on the Flat.—The summer culture of beans growing on flat ground in rows is the same, in as far as scuffling, hoeing, and drill-grubbing the ground are concerned, as on the raised drill. Almost the only difference is that the land is not set up with the double mould-board plough.

No Harbour to Weeds.—No amount of horse- and hand-hoeing should be grudged that may be necessary to make and keep the land free from weeds. It should be remembered that one of the objects in having beans sown in drills is to have the land well worked and cleaned.

Broadcast.—When beans are grown broadcast, no implement but the hand-hoe is of any avail in clearing the ground of weeds; and as hand-hoeing would require to be performed much oftener than time will allow, to keep the ground as clean as it should be, the consequence is that a crop of broadcast beans affords a harbour to weeds, unless growing weather pushes the bean plants forward to smother the weeds.

Cropping Beans.—After the bean plant has grown until all the pods are set, the practice of the garden indicates that, when the top of the plant is cut off in moist weather, at that period of its growth the crop will be sensibly increased. This is a probable result, it being a common observation that in moist weather the bean has a great tendency to grow in height long after the pods have ceased to form. As long as this tendency con-

tinues, the pods and beans do not enlarge; and the only mode of checking it is to cut off the top, when the vigour of the plants' growth will be solely devoted to the nourishment of the fruit.

Beans and Peas Mixed.—Beans and peas are often grown together, the seed being sown broadcast. The most general proportion is about one-third of peas to two-thirds of beans.

Botanical Character of Beans.—It was an observation of De Candolle, that "it is remarkable that the botanical character of the *Leguminosæ* should so strictly agree with the properties of their seed. The latter may be divided into two sections—namely, the first, *Sarcolobæ*, or those of which the cotyledons are thick, and filled with fecula, and destitute of cortical pores, and which, moreover, in germination do not undergo any change, but nourish the young plant by means of that supply of food which they already contain; second, the *Phyllolobæ*, or those of which the cotyledons are thin, with very little fecula, and furnished with cortical pores, which change at once into leaves at the time of germination, for the purpose of elaborating food for the young plant. All the seeds of the *sarcolobæ* are used as food in different countries, and none of those of *phyllolobæ* are ever so employed."

Ancient Notions regarding Beans.—The ancient Greeks had some strange notions regarding the bean. Thus Didymus the Alexandrian says: "Do not plant beans near the roots of a tree, lest the tree be dried. That they may boil well, sprinkle water with nitre over them. Physicians, indeed, say that beans make the persons that eat them heavy; they also think that they prevent night dreams, for they are flatulent. They likewise say that domestic fowls that always eat them become barren. Pythagoras also says that you must not eat beans, because there are found in the flour of the plant inauspicious letters. They also say that a bean that has been eroded becomes whole again at the increase of the moon; that it will by no means be boiled in salt water, nor, consequently, in sea-water," &c.[1]

[1] Owen's *Geoponika*, i. 82.

SOWING PEAS.

In recent years peas have been sown to a smaller extent than they were at one time in this country. They seldom take a prominent place as an ordinary rotation crop, but are largely grown near populous towns for sale in the green pod.

Peas give the best results on light and friable loamy soils of a calcareous character, or which had been recently dressed with lime or chalk. It is a general observation that annual weeds are encouraged in growth amongst peas; and the pea being a precarious crop, yielding a small return of grain, except in fine warm seasons, a mere good crop of straw is insufficient remuneration for a scanty crop of grain, accompanied with a foul state of land. Hence in many cases turnips have been substituted for peas.

Peas, for a long period, were invariably sown broadcast; but seeing their tendency to protect weeds, and that drill-culture rendered the land clean, the conclusion was obvious that peas sown in drills would admit of the land being cleansed. It was found that the straw by its rapid growth creeping along the ground soon prevents the use of the weeding instruments. To counteract this tendency, the practice was introduced of sowing peas and beans together, and while their seasons of growth coincide, the stems of the bean serve as stakes to support the bines of the pea. The proportion, as already stated, is about one-third of peas to two-thirds of beans.

Tillage for Peas.—It is somehow considered of little moment how the land shall be ploughed when the pea is to be sown by itself. Sometimes only one furrow after the stubble is given; and when the land is tender and pretty clean, a sufficient tilth may be raised in this manner to cover the seed, which requires neither a deep soil for its roots (which are fibrous and spreading near the surface), nor a deep covering of earth above them, 2 inches sufficing for the purpose. But a single furrow does not do justice to the land, whatever it may do for the crop. The land should be double drilled or grubbed after the spring ploughing.

Since the pea can be cultivated along

with the bean, it will grow on good strong soils; and its spreading roots enable it to grow on thin clays, where the bean does not thrive. But by itself, the pea, as has been indicated, thrives best on light soils. In clay, it produces a large bulk of straw, and the grain depends on the season being dry and warm; and as this is not the usual character of our climate, the yield is but indifferent.

Dung is seldom given to the pea when sown by itself, having the effect of forcing much straw with little grain.

When peas and beans are reaped together, they are separated when thrashed simply by riddling, the peas passing through the meshes of the riddle, while the beans are left upon the riddle.

Sowing Peas.—Peas are sown by hand when cultivated broadcast, and with the barrow when in rows, in every third, or in every furrow. With beans, they are sown by a barrow; on drilled land, broadcast by the hand; the seed falling to the bottom of the drills is covered by the harrows passing across the drills. Like beans, peas are sown on ploughed lea in some parts of England. On lea, the pea is dibbled in the harrowed surface, the holes being placed about 9 inches asunder. When varieties of the white garden-pea are cultivated in the field, as in the southern counties of England, these various modes of sowing them deserve attention; as also in the neighbourhood of large towns, where the garden-pea is cultivated and sent in a green state to the vegetable market.

The quantity of seed per acre varies, in drilling, from 2½ to 3 bushels per acre in the south, and sometimes as much as 4 in the north. The rows are usually from 12 to 15 inches apart. A little more seed is used in sowing broadcast.

The *varieties* of peas are very numerous.

Sowing Peas in Autumn.—Peas are sown in the field in autumn in some parts of England. Although manure is rarely given to peas sown in spring, it is given in moderate quantity to that sown in autumn. On clean oat-stubble the manure, 8 to 10 cart-loads to the acre, should be spread on the surface, and ploughed in with the common plough. In every third furrow the seed is sown with the bean drill-barrow. The ploughed surface should have two tines of the harrow, to close the openings in the ploughing and protect the seed from frost.

The crop ripens earlier than when sown in spring, and the land is worked, cleaned, and manured again for sowing wheat upon it in autumn. The after-culture and harvesting are the same as for peas sown in spring.

Summer Culture of Peas.

Although a common practice is to sow peas along with beans, yet, as they are also cultivated alone, it is necessary to bestow attention on them when so cultivated. When sown broadcast, the pea plant, growing quickly, especially in moist weather, soon overspreads the weeds growing along with it. But though it overspreads, it does not entirely destroy them. The consequence is, that the ground is left by the pea crop in a foul state.

When sown in rows, in every third furrow of the plough, or in raised drills, the ground is scuffled, hoed, and drill-grubbed, as are beans when sown in rows on the flat.

These operations require to be rapidly performed, the quick and straggling growth of pea-stems affording neither time nor room for dilatory work.

GERMINATION OF SEEDS.

At this stage it will be interesting to introduce the following notes on the germination of seeds, carefully revised for this edition by Professor A. N. M'Alpine:—

Though apparently lifeless to the sight and touch, the healthy seed of a plant is a living object, for it contains within it a dormant embryo plant capable of being excited to active life. What life is we do not know, perhaps never shall—it is a secret which Nature has hitherto kept

to herself; but we do know the circumstances in which seeds must be placed in order that they may germinate and develop the embryo within into a seedling plant. The proof of the excitement is in their germination, which is the first movement towards the production of a plant.

Conditions essential for Germination. — Now, the circumstances which excite germination are the combined action of air, heat, and moisture. These conditions must be satisfied before the seed will germinate satisfactorily. They may all be supplied to the seed, and its germination secured in the air as certainly as in the soil; but on the development of a root, most plants would die if kept constantly in the air. The soil supplies all the requisites of air, heat, and moisture to the seed in a better state than the atmosphere could alone; and it continues to supply them not only when the seed is germinating and producing the seedling, but also during the entire life of the plant till maturity is reached.

A vital seed placed in the soil is affected by three agencies—1, physical; 2, chemical; and 3, physiological — before it can produce a plant.

Air and Germination. — When a seed is placed in pulverised ground, it is *physically* surrounded with air; for although the particles of soil may seem to the eye to be close together, on examination it has been found that the interstices between the particles occupy about ¼ of a given volume of soil. Hence, 100 cubic inches of pulverised soil contain about 25 cubic inches of air. Therefore, in a field the soil of which has been ploughed and pulverised, and cleared of large stones, to the depth of 8 inches, 1 acre of it may contain about 12,545,280 cubic inches of air; and hence also, as every additional inch of depth pulverised calls into activity some 260 tons of soil, at 1.48 of specific gravity, so the ploughing up of another inch of soil not before stirred and not hitherto containing any air, introduces into the workable soil an addition of perhaps nearly 1½ million cubic inches of air. Thus, by increasing the depth of pulverised soil, we can provide a depot of air to any extent for the use of plants.

It should be noted that it is the oxygen of the air that is of chief importance in germination.

But this air must be above a certain temperature ere the seed will germinate —it must be above the freezing-point, else the seed will remain dormant and not display its vital powers. It is also

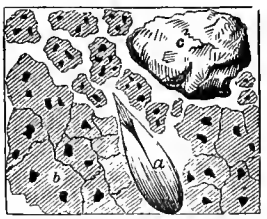


Fig. 435.—*Cloddy and stony soil.*
a The seed. *b* Hard clots. *c* A stone.

desirable that the soil should be well pulverised, and not as in fig. 435, where a seed is placed among hard clods on the one side, and near a stone on the other, conditions not likely to favour the development of strong regular plants.

Moisture and Germination. — Fig. 436 represents the seed placed in a pulverised soil, all the interstices of which are entirely occupied by water instead of

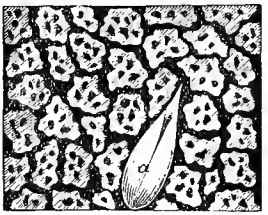


Fig. 436.—*Soil with water and without air.*
a The seed.
White spaces—pulverised soil. Black spaces—water.

air. It is clear that, in this case too, the seed, being deprived of air, is not placed in the most favourable circumstances for germination. Besides the direct exclusion of the air, the water, on evaporation, renders the earth around each seed much colder than it would otherwise be.

But total want of moisture prevents germination as much as excess. Fig. 437 shows the seed placed in pulverised soil, and the interstices filled with air, with no moisture present between or in the

particles of soil. In such a state of soil, heat will find an easy access to the seed, and as easy an escape from it.

Fig. 438 represents the seed in soil completely pulverised. Between every particle of the soil the air finds easy access to the seed, and in the heart of every particle of soil moisture is lodged,

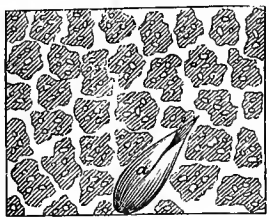


Fig. 437.—*Soil with air and without water.*

a The seed.
White spaces—air and heat.
Dark spaces—dry pulverised soil full of air.

which the seed can draw upon and use. All that is here required in addition is a favourable temperature, which the season supplies. Now all the conditions are fulfilled, everything is favourable, and germination proceeds smoothly without interruption.

Composition of Seeds.—The *chemical* components of seeds are organic and inorganic substances. The organic sub-

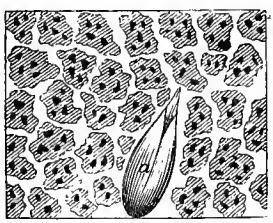


Fig. 438.—*Soil with water and with air.*

a The seed.
White spaces—air and heat.
Dark spaces—pulverised soil with darker water.

stances are of two classes, the nitrogenous and the non-nitrogenous; the inorganic, also of two classes, but comparatively small in amount, are the minerals from the soil and the water. The nitrogenous substances consist of albuminoid matter analogous to the caseine of milk, the albumen of the egg and of blood, and the fibrine of the flesh of animals; the non-nitrogenous consist of starch and cellulose, with fatty and oily matters rich in carbon and hydrogen.

Changes incident to Germination.—When a seed is consigned to the ground, the first change which takes place in it is physical—it becomes increased in bulk by the absorption of moisture; and being also surrounded by air, it only requires the requisite degree of temperature to excite its vitality into action. If there is no moisture present, as in fig. 437, it will remain in a state of dormancy until moisture arrive, and in the meantime may either become the prey of the many animals which inhabit the soil, eager for food, or be scorched to death by heat. If it is placed in excess of moisture, as in fig. 436, its germination is prevented by the exclusion of the air, and its tissues are, by maceration in the water, destroyed by soil germs.

When the seed begins to germinate, a digestive juice is formed at the expense of its albumen, and the active ingredient in this juice is the same as in our own saliva, namely, *diastase*. The function of diastase is important. It is to convert the insoluble starch of the seed into soluble dextrine and sugar into a form fit to nourish the growing embryo plant within the seed. The digestive power which diastase has is most extraordinary. One part of diastase will convert into sugar no less than 2000 parts of starch. The diastase thus converts the starch which it finds into a state useful for the support of the embryo plant at its start in life.

The Embryo.—"Under fitting circumstances," says Lindley, "the embryo which the seed contains swells, and bursts through its integuments; it then lengthens, first in a direction downwards, next in an upright direction, thus forming a centre or axis round which other parts are ultimately formed. No known power can overcome this tendency, on the part of the embryo, to elevate one portion in the air, and to bury the other in the earth; but it is an inherent property with which nature has endowed seeds, in order to insure the young parts, when first called into life, each finding itself in the situation most suitable to its existence—that is to say, the root in the earth, the stem in the air."

The Young Plant or Seedling.—

When the germ has become a seedling plant, it is found to be possessed of a sweet taste, which is owing to the presence of grape-sugar in the sap which has already begun to circulate through its vessels. There is little doubt that the grape-sugar is formed subsequently to the appearance of diastase, and that diastase is merely a digestive agent for converting the insoluble starch into the soluble and diffusible form of sugar. The parts of this seedling plant are a root down in the ground for using the soil, and a leafy stem for using the light and air.

Seed dissected.—A seed always consists of a protective skin without and a germ or embryo within. Along with this embryo a mature seed always contains a comparatively large amount of food stored away sufficient to nurse the embryo till it has developed into an independent seedling plant. Fig. 439 represents a grain of wheat magnified, and so dissected as to show its component parts. It consists of two skins, an outer and an inner. Within the inner skin the nutritive matters, called the starch and albumen, are situate. There is also the little scale or sucker through which the nutritive matter passes in the sweet state, when the grain is germinating. The important part is *d* in the figure; its apex grows out as a leafy shoot, and a bunch of outgrowths from its base form the first roots.

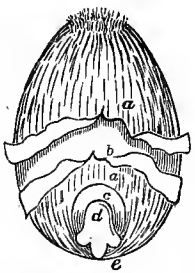


Fig. 439.—*Component parts of a grain of wheat.*

a a Outer skin.
b Inner skin.
c and *d* together, The germ or embryo.
c Scale or sucker.
d That part of the embryo which develops into roots and leafy stem.
e Base of grain.

Multiple Stems or "Tillering."—The embryo in the seeds of plants possesses such a structure that only 1 stem can proceed from them; but in many agricultural plants, particularly in the cereals, which yield human food, a remarkable departure from this structure is observed at a very early stage of life. In them the young plant is usually thickened towards its base, and so organised that, instead of 1 stem, 3 or 4 may spring from 1 grain.

The thickened base of the young plant has the habit of producing pimple-like projections, and each of these may become an extra shoot. The peculiarity mentioned may be observed in fig. 440. The figure represents a grain in a state of germination. The shoot of the embryo has left its sheath, and two tiller shoots have been produced: the one to the left is as yet a mere pimple-like projection, whereas the other to the right is further advanced and partially evolved. The rootlets are seen extending downwards in a bunch. The root of the embryo has developed into a main rootlet, while 3 projections at the side of its base have also developed into rootlets. On other kinds of seedlings there would have been but 1 rootlet, since on these the basal projections do not form.

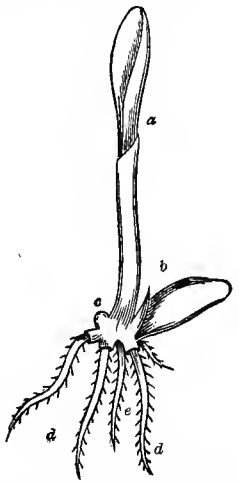


Fig. 440.—*Wheat plant in the state of germination.*

a First shoot of the embryo leaving the sheath.
b A tiller shoot just evolved.
c Tiller shoot yet unevolved.
d d Rootlets formed at the side.
e Main rootlet.

Different Methods of Sowing and Germination.

Disadvantage of Broadcast Sowing.—Of all the modes of sowing seeds, none requires so much seed as the *broadcast*. However regularly the land may have been ploughed, seed sown broadcast

will braird irregularly—some falling into the lowest part, some upon the highest, some scarcely covered with earth by the harrows, some buried as deep as the ruts of tines have penetrated. To make the land smooth by harrowing, previous to sowing the seed, would not cure irregular covering, since it is impossible to cover a large seed as that of the cereals with tines without the assistance of a rough surface of mould. In fig. 441 the furrows are well and regularly ploughed; but while it is obvious that the seeds, when scat-

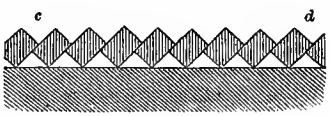


Fig. 441.—*Well-ploughed regular furrow-slices.*
c to *d* Regularly ploughed furrow-slices.

tered broadcast from the hand, will fall mostly in the hollows between the furrows, yet some will stick upon the points and sides of the furrow-slices. The seeds will thus lie in the ground, as in fig. 442, those which fell into the hollows of the

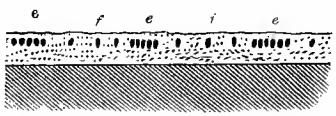


Fig. 442.—*Positions of seeds on regular furrows.*
e e e Seeds fallen in the hollows of the furrows.
f f Seeds scattered upon tops and sides of furrows.

furrows being thicker than the seeds which stuck upon their tops and sides. But it is not at all likely that the seeds will be so regular as represented. Some will be too deep and others too shallow in the soil, whilst some will be left on the sur-

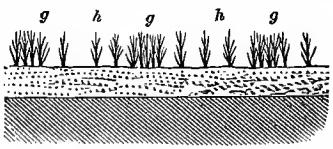


Fig. 443.—*Irregular braird upon regular furrows.*
g g g Plants growing in clumps.
h h Plants growing scattered.

face. From irregular deposition, plants will grow in irregular positions, as in fig. 443, where some are in clumps from the bottom of the furrows, and others are straggling too far asunder. Where the seeds have been deposited at different depths, the plants will grow at more irregular heights than in the figure.

When the land is ill-ploughed, the case

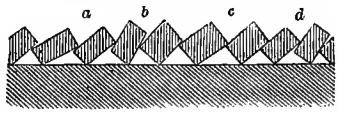


Fig. 444.—*Ill-ploughed irregular furrow-slices.*
a Furrow-slice too flat. *c* Furrow-slices too wide.
b Furrow-slice too high. *d* Furrow too deep.

is still worse. Fig. 444 shows the irregular furrows from bad ploughing. Bad ploughing entails bad consequences in any crop, but especially in cereal ones, inasmuch as irregularity of surface can-

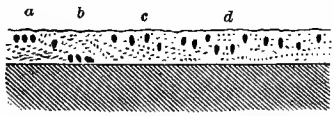


Fig. 445.—*Irregular positions of seed on ill-ploughed furrows.*
a Seed clustered and covered shallow.
b Seed clustered and buried deep.
c Seed scattered and covered shallow.
d Seed scattered and covered deep.

not be amended by a series of future operations, as in green crops. In the irregular furrow-slices of fig. 444, some are narrow and deep, some shallow, some too large, some of ordinary depth, and

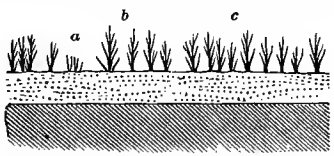


Fig. 446.—*Irregular braird on ill-ploughed furrow.*
a Late plants. *b* Early plants.
c Regular growth of plants.

some too high and steep. The seed sown on these irregular furrows is shown in fig. 445, where some are clustered together with a shallow covering, others also clustered, but buried deeply, whilst many are scattered irregularly at different depths. Such a deposition of seed must make the braird come up irregularly; and the plants have not the chance of reaching maturity at the same time.

In fig. 446, where the seed was covered deeply, the plants will come up late; with shallow covering, they will come up

early, and will push on in growth; while the remainder, coming up regularly, will form the best part of the crop. Where a crop of cereals does not mature at the same time, the grain cannot be equal in the sample.

Advantages of Drill Sowing.—One obvious advantage of sowing with a *drill* over a *broadcast* machine, is the deposition of seed at the same depth, whatever depth may be chosen. Fig. 447 shows the seed deposited at regular intervals.

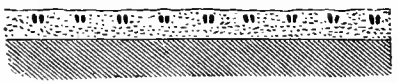


Fig. 447.—*Regular depth of seed by drill-sowing.*

The braird is shown at the same regular intervals in fig. 448, and its produce will reasonably be of the same quality. For drill sowing the land has previously received all the harrowing it requires for the crop, and by the coulter or tongue of the machine the seed is deposited regularly at a uniform depth and thickness.

Still there are many who prefer broadcast sowing, and, with careful preparation of the seed-bed, and skilful performance of the work of sowing, it will usually give satisfactory results.

Drill sowing leaves a blank between the rows of plants, which encourages the growth of weeds. On the other hand,

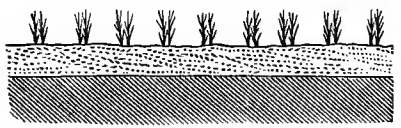


Fig. 448.—*Regular braird from drill-sown seed.*

this system permits of hoeing after the plants are advanced considerably, and if this operation is carefully performed by hand or horse-hoe it is usually found to be beneficial to the crop.

Dibbling.—*Dibbling* is distributing seed by means of a dibble at given distances, and at a given depth in the soil. The distribution by this system may either be in rows or broadcast. The difference betwixt dibbling and drilling is, that in drilling the seed is placed in lines, while dibbling places it at uniform distances in the line. The object of dibbling is to fill the ground with plants with the smallest quantity of seed. The seed planted in lines with the dibble appears as in fig. 447, and the plants like those in fig. 448. The depth of the seed and brairding of the plants are as uniform as in drilling, but the plants stand independent of each other in dibbling.

As would be readily understood, dibbling is not suitable where any considerable extent has to be sown, but it is very useful in filling up blanks.

Waste of Seed.—When sown in all these ways in equal quantities, the *waste of seed*, as determined by experiment, is surprising. *Wheat* at 63 lb. the bushel gives 87 seeds to 1 drachm, avoirdupois weight, or 865,170 to 1 bushel. Now, 3 bushels of seed sown broadcast on the acre gives a total of 2,595,510 seeds. Suppose that each seed produces 1 stem, and every stem bears 1 ear containing the ordinary number of 32 seeds, the produce of 1 acre would be 96 bushels. How far this exceeds the usual return need hardly be stated. Rarely, indeed, have we known the produce of wheat to exceed 64 bushels on 1 acre, so that in this case 32 bushels, or 33 per cent of the seed, would be lost, while in an ordinary crop of 40 bushels the loss of seed would be 58 per cent.

The waste in *barley* seed is estimated thus: Chevalier barley at 57 lb. the bushel, and 75 grains to 1 drachm, avoirdupois weight, gives 665,242 seeds; 4 bushels of seed sown on 1 acre gives 2,660,968 seeds; and allowing 1 stem from each seed, and 1 ear of 32 seeds, the produce would be 128 bushels! Even with an exceptional crop of 64 bushels there would be a loss of 50 per cent, while on the ordinary crop of 48 bushels the loss would be nearly 69 per cent.

In like manner the loss upon *oats* may be estimated, and will be found to be often more than one-half the quantity of seed sown.

In all these cases only 1 stem from 1 seed is reckoned, but many of the seeds produce 2 or 3 or more. The *actual* loss of produce sustained is thus not so great as of seed.

Another view of the waste of seed is this: 2,595,510 seeds of wheat on 1 acre give 536 seeds to 1 square yard; 2,660,968

seeds of barley give 550 seeds; and 5,879,808 seeds of oats give 1214. In wheat and barley the proportion of seed is in proportion to their respective weights, but in oats the seed is more than double in proportion to the weight, because of the thick husk of the oats.

Waste of Seeds by different Methods of Sowing.—P. M'Lagan of Pumpherston made experiments to ascertain the waste of seed in sowing oats in the three different ways of dibbling, drilling, and broadcast. The oats weighed 42 lb. the bushel. The dibbled holes were made 6 inches apart, and 6 inches between the rows, making 36 holes in 1 square yard, and each hole was supplied with from 1 to 4 seeds, making the quantity sown from 1 peck to 4 pecks on 1 acre; and the seeds sown drilled and broadcast were in the same proportion. In drilling and dibbling, the seed was inserted 3½ inches into the ground. The results were as follows:—

	Dibbled.	Drilled.	Broadcast.
From 36 grains sown	26 plants	32 plants	19 plants came up.
" 72 "	49 "	53 "	52 "
" 108 "	75 "	78 "	68 "
" 144 "	120 "	94 "	87 "
360	270	257	226
Percentage	75	71	62

As might have been anticipated, there was not much difference in the brairding of seed dibbled and drilled, since the seeds were deposited much in the same position in the soil.

The *broadcast* involves a substantial loss—an anticipated result, since many of the seeds were unburied, or buried too deeply. The seeds were sown on the 19th March, and the thickest sown of the drilled and broadcast brairded first on the 16th April. Thick-sown seeds always braird earliest.

The experiments were extended by sowing 7 pecks of oats drilled, or 252 seeds to the square yard, and from these 208 plants came up, giving a percentage of 82. There were also sown 24 pecks to 1 acre broadcast, or 864 seeds to 1 square yard, which produced 570 plants, giving a percentage of 67, only a little more than in the former case of broadcasting. Thus, the smallest number of seeds gave the largest return of plants brairded.

G. W. Hay of Whiterigg, Roxburghshire, also made several experiments at the same time, by dibbling and drilling wheat, barley, and oats, and sowing oats broadcast. The *dibbled* seeds were put into holes within 3 inches square to the number of 1, 3, and 6 grains in each hole, which gave respectively 144, 432, and 864 grains to the square yard. The seeds were sown on the 16th March, and the plants counted on the 8th May. The results were these:—

DIBBLED.

	After 144 seeds.	After 432 seeds.	After 864 seeds.	
Of wheat	97	296	616	1009 plants came up.
Barley	95	335	687	1117 "
Hopetoun oats	129	403	800	1332 "
Potato oats	135	407	823	1365 "
Birley oats	125	413	777	1315 "
Sheriff oats	132	405	751	1288 "
Percentage of				
Wheat came up	67	69	71	average 69
Barley	66	79	79	" 75
Oats	90	94	91	" 92

On the 25th March similar seeds were sown in *drills* at the same rates per square yard, and the plants counted on the 8th May, when the results were:—

DRILLED.

	After 144 seeds.	After 432 seeds.	After 864 seeds.	
Of wheat . .	105	327	652	1084 plants came up.
Barley . .	86	318	747	1151 "
Hopetoun oats .	139	408	798	1345 "
Potato oats .	137	407	795	1339 "
Percentage of				
Wheat came up .	73	73	75 average	74
Barley . . .	60	73	86 "	73
Oats . . .	96	94	92 "	94

On comparing the brairds of the drilled with the dibbled seeds in the barley and oats little difference is apparent, while the wheat incurs less loss of plants when drilled than when dibbled, in the ratio of 1009 to 1084. Comparing the results obtained by both experimenters with oats, we find that Mr Hay obtained a braird of $^{9}/_{10}$ of the seed in dibbling and drilling; while Mr M'Lagan obtained only $^{7}/_{10}$, and, in oats broadcast, $^{6}/_{10}$.

Tillering.—After a lapse of ten days, on the 18th May, when rain had fallen in the interval, the plants after broadcast were counted, and were unexpectedly found greater in number than the seeds sown. The plants must have tillered after the rain, and the tillering was ascertained to be from—

Seeds.		Plants.	Tillering.
315	Barley	360 =	one-sixth.
325	"	405 =	one-fourth.
471	Sheriff oats	930 =	double.
520	" "	648 =	one-fourth.
666	Potato "	704 =	one-sixteenth.

The advanced state of the plants after the rain indicates that in spring oats tiller very strongly and rapidly.

Quantity of Seed.—Taking the respective quantities of seed sown on 1 square yard by both experimenters, they will be as follows on 1 acre:—

Seeds.		Seeds.	Per acre.
36	per square yard =	174,240 =	1 peck.
72	" =	348,480 =	2 "
108	" =	522,720 =	3 "
144	" =	696,960 =	1 bushel.
288	" =	1,393,920 =	2 "
432	" =	2,090,880 =	3 "
576	" =	2,787,840 =	4 "
720	" =	3,484,800 =	5 "
864	" =	4,181,760 =	6 "

Produce from different Methods of Sowing.—Kenyon S. Parker made a comparative experiment between drilling, dibbling, and broadcasting wheat on clover lea, and the results show that drilling produced more grain than dibbling; while the straw was longer and stronger, the ears larger, and the seeds heavier in the dibbled, thus:—

	1 acre. bush. peck.		1 acre. qr. bush. gal.	Weight. per bush. lb.
Broadcast	1 3	produced	3 7 1	62
Drilled, at 12 in.	1 2	"	4 3 1	63
Dibbled	1 0	"	4 3 0	63½

Importance of economising Seed.—The questions to which such results give rise are, What quantity is too thick and what too thin sowing? and, What is the least quantity of seed to yield the largest crop? The inquiry assumes much importance when we consider that from $^{1}/_{10}$ to $^{1}/_{14}$ of all the grain grown in the country is every year put into the ground as seed. A small fraction of either of these proportions saved would add a profit to the farmer to that extent. If 1 bushel of seed could be saved on each acre, a simple calculation would show that the gain to the farmer would amount to a vast sum of money.

Thick and Thin Sowing — Thick and thin sowing of seed is a subject of controversy among farmers. The saving of seed would be a sufficient argument in favour of *thin* sowing, provided the same return were received. But the results have been found to vary. There are many conditions to be considered in deciding as to the quantity of seed to be sown. The nature and condition of the soil, the climate, the quality of the seed itself, and even the character of the season, must all be kept in view.

Hewitt Davis, Spring Park, Croydon, who occupied 800 acres of high-rented poor soil, upon a warm subsoil of chalk, stated that "the practice throughout England is to sow 2 or 3 bushels of

wheat to 1 acre, and the yield seldom reaches 40 bushels, and more commonly less than 20 bushels, so that $^1/_{10}$ at least of the crop grown is consumed as seed, whilst 1 single grain of wheat, planted where it has room to tiller out, will readily produce many 100-fold. The knowledge of these facts has induced me, in the course of years, to make a variety of experiments, the results of which have clearly shown me that, independent of the waste, a positive and serious injury of far more consequence is done to the crop from sowing so much seed. I bear in mind that, if so much be sown as to produce more plants than the space will allow to attain to maturity, the latter growth of the whole will be impeded, and a diseased state will commence as soon as the plants cover the ground, and continue till harvest." The quantities of seed Mr Davies determined on sowing, in accordance with these reasons, are, for—

Rye . . .	1¼ bushel	sown in	August and September.
Winter barley . .	2 "	"	September.
Tares . . .	1½ "	"	3 sowings in Aug., Sept., and Oct.
Oats . . .	6 pecks	"	January, February, and March.
Barley . . .	5 "	"	January, February, March, and April.
Wheat . . .	3 "	"	September and October.
Peas . . .	9 "	"	December, January, and February.
Beans . . .	9 "	"	September and October.

The returns obtained by Mr Davis, after these scanty sowings, were 5 quarters of wheat, 13 quarters of oats, and 8 quarters of barley per acre on "very inferior land," from the manure available on the farm.[1]

Mr Barclay, Eastarch Farm, Surrey, *drilled* 2½ bushels of wheat at 9 inches apart, and obtained 37 bushels at 64¾ lb. per bushel, and 70 trusses of straw, value £16, 6s. He *dibbled* 1 bushel 3 pecks at 9 inches apart, and had 37 bushels at 64 lb. per bushel, and 72 trusses of straw, at a value of £15, 12s. 9d. He sowed *broadcast* 2½ bushels, and had 40 bushels at 65 lb. per bushel, and 84 trusses of straw, the value being £18, 1s. Here broadcast and thick sowing prevailed. Soil, deep loam on chalk subsoil.[2]

On the comparative merits of thick and thin sowing, it has been contended that experience has established that,—thick sowing is advisable on newly-broken-up land, containing a large amount of vegetable matter in an active state of decomposition, when it is beneficial in repressing, by its numerous roots and stems, that exuberance of growth which produces soft and succulent stems, which are easily lodged, and produce unfilled ears. Thin sowing has a tendency to make the roots descend deeply; and where a ferruginous subsoil exists, thick sowing keeps the roots nearer the surface, away from it. Thin sowing develops a large ear, grain, and stem, but delays maturity. Thick sowing on old land in high condition renders the plant diminutive and weak in straw, and hastens its maturity before the ear and grain have attained their proper size. Thin sowing in autumn affords room to plants to tiller and fill the ground in early spring, while thin sowing late in spring does not afford time to the plant to tiller. Thick sowing in autumn makes plants look best in winter, but gradually attenuates them in spring. Thin sowing makes plants look worst in winter, but to look better and fuller as the harvest approaches.

Different Methods of Sowing Compared. — On comparing the broadcast, drilled, and dibbled methods of sowing the cereal grains, it must be owned that the *broadcast* incurs a loss of seed by some being exposed on the surface, and others sent too deeply into the soil. Such effects are produced whether by hand or machine sowing, and cannot be avoided until a machine is contrived to sow corn broadcast at a uniform depth.

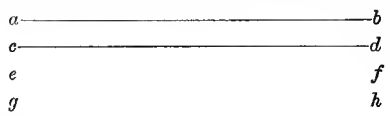
The *drill* does not work well in stony ground, which easily jolts the coulters to one side, or they displace small stones, or ride over large ones; while where land-fast stones or subjacent rocks are near the surface, they would be broken. Where there are many stones the drill should

[1] Davis's *Waste of Corn by Too Thick Sowing*, 6-12.

[2] *Jour. Eng. Agric. Soc.*, vi. 192.

not be used. Where the soil is fine, drilling has the advantage of having the land smooth before the seed is sown, and then seed escapes disturbance by cross-harrowing.

Dibbling may be done by a hand-dibble, or with an implement having pins attached to the bottom of a spar of wood, and which pins are thrust into the ground with a pressure of the foot. Another method is, to thrust small hand-dibbles through holes formed in a thin board of wood. In all these modes the seed is deposited in the holes at stated distances—perhaps 7 inches between the rows, 4 inches apart in the rows, and 2½ inches in depth. The earth is put over the holes with the foot. When a man uses a small dibbler, a convenient mode of keeping the lines straight is this: Take 2 long lines and stretch them along the side of the field, at a determinate distance between them; *a b* and *c d* are the 2 lines at a distance between them of *a c* and *b d*.



Let him dibble in the seed along *a b*, and when at *b*, let him shift that end of the line from *b* to *f*, and then dibble the seed in from *d* to *c*, where let him shift the end of the line at *a* to *e*, which brings the line straight from *f* to *e*. Before starting with the dibbling from *e*, let him remove the end of the line at *c* to *g*, and then dibble the seed from *e* to *f*, where he shifts the end of the line from *d* to *h*, which brings the line straight from *g* to *h*. Shifting the line from *f* to *i*, he proceeds as he did at *b*, and so on alternately from one side to the other.

Dibbling-machines.—The dibbling-machine first brought into notice was invented by James Wilmot Newberry, Hook Norton, Chipping Norton, Oxfordshire. It is ingenious and elaborate in construction, and deposits every kind of corn at given distances, in any quantity, with the utmost precision. Fig. 449 is a view in perspective of a 1-rowed machine. It consists of a hollow flat disc, which contains the machinery that directs the corn from a hopper into hollow tubes, 18 of which are connected with and project from the circumference of the disc like the spokes of a wheel from its nave, and their points pass through a large outer ring, which retains the hollow tubes or distributors of corn in their respective places, and prevents them sinking into the ground beyond the requisite depth. A fore-wheel, which is placed between the extremities of the stilts or handles, prevents the large outer ring being pressed closer to the ground than needful. A man pulls the machine forward by means of a rope attached to the fore part of the stilts, or, what is better, a bridle and shackle might be mounted there, for yoking a pony or horse to draw the machine. As the wheel is drawn forward by the horse, it turns round by contact with the

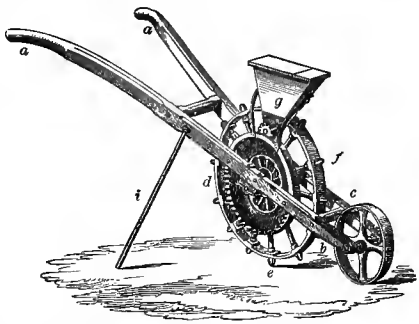


Fig. 449.—*Newberry's one-rowed dibbling-machine.*

a a Stilts.
b Fore part of stilts.
c Fore-wheel.
d Hollow flat disc.
e Projecting points or dibbles.
f Large outer ring.
g Hopper.
i Stay to support the machine.

ground, the projecting points of the hollow tubes acting as dibbles and making holes in the ground; a portion of the dibbles, before leaving the ground, slides up upon the upper part, making an opening through which the corn is deposited in the holes. The corn descends of the requisite number from the hopper by means of feeding-rollers, moved by a pinion, which is set in motion by teeth placed on the circumference of the flat disc. The disc is supported in its centre by an axle revolving in its ends on plummer-blocks. In using this machine, a man holds by the two stilts, while a man or horse draws the machine in the given line. The line not being in the line of the body of the drill, a rigger is required for the horse to be yoked to. A stay supports the machine when at rest. This

1-rowed dibble is said to be well suited for sowing mangel seed on the top of the drill.

Another dibbling-machine, presented to public notice by Samuel Newington, of Knole Park, Frant, Kent, is shown in fig. 450—a view in perspective of one having 6 depositors. The box in front contains the corn, and the points of the depositors are seen to rest upon the ground, which has been harrowed smooth for the purpose. The depositors place the seeds at the desired depths, deeper or shallower, being kept in their places by pinching screws. The machine is worked by taking hold of the upper rail by both hands, and, on pressing upon it, the depositors, when withdrawn, leave the requisite number of seeds in each hole the depositors have made, by the machinery in the interior of the machine. By pressing down the upper handle, the depositors press every seed firmly into a solid bed, which is so small as to preclude the fear of its containing water, and yet completely buries the seed. By changing the cups, the quantity of the corn is regulated, as well as the description of corn. With a machine having six depositors, 1 man can dibble 1 acre in 10 hours, so that the cost of dibbling may be easily ascertained by the rate of wages in the district.

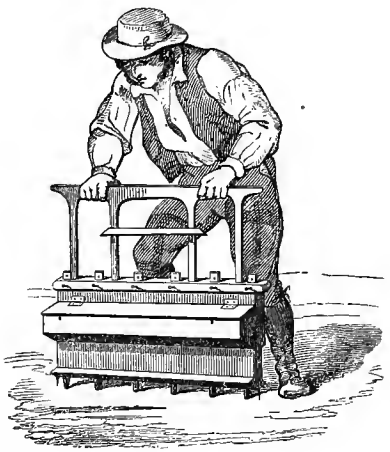


Fig. 450.—*Newington's 6-rowed dibbling-machine.*

In using the machine after the first line is laid off straight next the fence, the workman continues to keep the other lines straight at the stated distance by the mark left on the ground by the machine. The seeds are put in at 4 inches apart in the rows, and the quantity is varied by either altering the distance between the rows or increasing the number of seeds in each hole, but it is not desirable to exceed 3 seeds in 1 hole. The cups which contain the grains are of 4 sizes, and can be easily removed or replaced by means of screws.

As already indicated, dibbling is too slow a process for the modern necessities of farm practice, but on a small scale, and for filling up blanks, it may be pursued with advantage.

Deep and Shallow Sowing. — Another circumstance which affects the relation between the grains sown and the plants produced, is the *depth* to which the corn is buried in the ground. In ill-ploughed land, when the corn is sown broadcast, falling between ill-assorted furrows, some of it may sink to the bottom of the furrow-slice, where it will be buried, to become dormant or lose its vitality. Corn is differently affected by depth in soil, some sorts germinating at a considerable depth, whilst others become dormant or die if placed at a smaller depth below the surface of the ground. A stem of barley has been traced to a depth of 9 inches, while oat seed buried 7 inches cannot be depended on to braird. This accounts for oats which had slipped to the bottom of the furrow-slices of lea and perished. The risk of thus losing seed in fresh-ploughed lea induces us to recommend partial harrowing of ploughed old lea before the seed is sown.

Wheat and all cereals possess a peculiarity in the growth of the root. The grain will bear to be deep-sown—not so deep as barley, but deeper than oats. Most wheat seeds may germinate at a depth of 6 or 7 inches, but sowing at that depth is risky, for the crop will likely be thin. After the germ of wheat has developed its first leafy stem, it puts out another set of roots about 1 inch below the surface. The deeper may be called the *seminal*, and the upper the *coronal* root of the wheat plant. Fig. 451 shows the position of the roots under the surface, where *a* is the grain with its seminal roots *c*, and the stem *b*

rising from it to the surface of the ground at *f*, above which is the stem with its leaves. About 1 inch below the surface *f*, at *d*, are formed the coronal roots, *e e*, and this same spot forms the site from which the tillers are sent forth. At whatever depth the seed may have been sown, the coronal roots are formed at 1 inch below the surface.

"As the increase and fructification of the plant depend upon the vigorous absorption of the coronal roots, it is no wonder that they should find themselves so near the surface where the soil is always the richest. I believe I do not err when I call this *vegetable instinct*. In the N. counties wheat is generally sown late. When the frost comes, the *coronal* roots, being young, are frequently chilled. This inconvenience may, however, be easily prevented by sowing more early, and burying the seed deeper. The seminal roots, being out of the reach of frost, will then be enabled to send up nourishment to the crown by means of the pipe of communication."

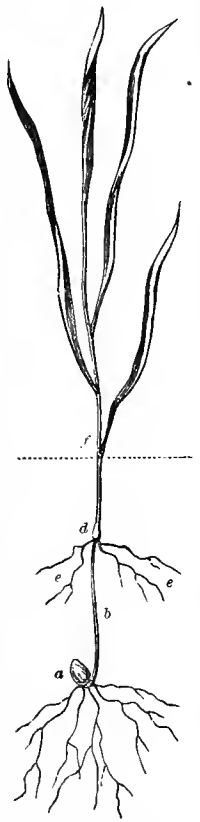


Fig. 451.—*Double roots of deep-sown wheat.*

Now the form which the plant assumes, when sown near the surface, is different, as in fig. 452, where *a* is the seed with its seminal roots; *b*, the stem or pipe of communication between them and the coronal roots *c c*, a little beneath the surface *d*. The coronal roots *c c* being at a short distance from the surface, the pipe of communication is at its shortest. "Hence it is obvious," continues the same writer, "that wheat sown superficially must be exposed to the frost, from the shortness of the pipe of communication placing the seminal roots within reach of the frost. The plant, in that situation, has no benefit from its double set of roots. On the contrary, when the grain has been properly covered, it depends almost entirely on the coronal roots, which, if well nourished during the winter, will send up numerous stalks in spring; and on the tillering of the corn the goodness of the crop principally depends; but if not well nourished there will be no tillering. A field of wheat dibbled, or sown in equidistant rows by the drill, always makes a better appearance than one sown with the harrow. In the one the pipe of communication is regularly of the same length, but in the other it is irregular, being either too long or too short."[1] The conclusions these statements would warrant in practice are: That wheat sown before winter should be deeply covered with earth, to be beyond the reach of ordinary frost; that in spring the coronal roots will set up abundance of tillers or stools; that wheat sown in spring should be lightly covered, the tillers being few; that autumn wheat should be drilled to secure the pipes of communication between the seminal and coronal roots being long and uniform; that spring wheat should be sown broadcast; and that autumnal wheat should have a smaller quantity of seed than spring wheat.

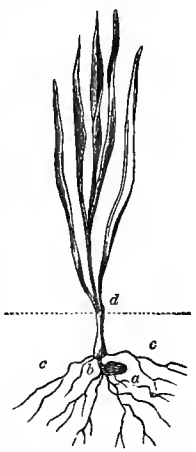


Fig. 452.—*Roots of shallow-sown wheat.*

Tillering.—The property of the cereal plants to *tiller* or *stool out*—that is, to send up a number of stems from the same root—is a valuable one in an economical point of view. But for this property, when the first shoot of the cereal happens to be destroyed by insects under

[1] *Georgic. Ess.*, i. 67-69.

ground, or by unfavourable environment, or by frost, or when young plants are injured by insects as they appear above the surface, the crop would be so scanty that it would be ploughed up by the farmer, and another substituted in its stead. The extent of tillering depends on the state of the soil and weather, and on the space allowed the plant to spread in. A loose soil, admitting the young shoots to penetrate easily, encourages tillering more than a stiff hard soil. Yet wheat tillers best on a moderately firm clay soil in good heart, for there the plant has manufactured a sufficient food-supply to give the tiller shoots a good set-off. If the plants have room enough, moist warm soil and sunny weather promote tillering to the utmost.

Unless plants have space for their roots and light for their shoots, they will not tiller and become strong plants, overcoming and killing their weaker fellows.

The question which such an occurrence gives rise to is, Whether it is better to allow few plants to fill the ground by tillering, or to fill the ground at once with the requisite number of plants? The answer to this question must be given conditionally. In naturally fertile soils, and in those rendered fertile by art, tillering will readily take place, and should be encouraged, inasmuch as the straw and ears of tillered plants are much stronger and larger than those of single plants. At the same time, the ears are less evenly ripe, for the tiller shoots are younger than the leading shoot that gave them birth. In favourable soils a small quantity of seed will suffice in early spring, and it is in that season that tillering takes place in a most marked degree; but the seed must not be sown so deeply nor so late as to deprive the plant of time for tillering, so as to occupy the ground fully.

The extent of tillering is sometimes remarkable. Le Couteur mentions a downy variety of wheat which tillers to the extent of 32 stems,[1] and from 5 to 10 stems are a common tillering for ordinary varieties of wheat. Barley also tillers, though late and thick sowing, with quick growth, overcomes that tendency. Oats indicate fully as strong a tendency to tiller as wheat. In weak soils, and soils in low condition, the tendency to tiller is much checked, each single root being conscious of its inability to support more than its single stem. Hence the practice is to sow more seed in low than in high conditioned land, and yet the ability to support the larger number of plants is in an inverse ratio. Yet what can the farmer do but sow as many seeds as will produce as many plants as will occupy the soil? The best way for him to escape from the dilemma is to put the soil in high condition, and reap the advantages derivable from tillering.

If, however, uniform grain for selling is the chief desideratum, thick sowing to prevent tillering may then be advisable.

Destruction of Seed.—The great loss in plants compared with the numbers of seed sown may be accounted for by natural causes. Birds pick up seeds exposed on the surface after broadcast sowing. Many vermin, such as the rabbit, devour the young germ as it penetrates the soil, and many insects subsist on the stems and roots of young plants.

Frost and cold winds which come upon the young plant when specially tender and unprepared often account for much destruction.

Transplanting.—A mode of saving seed to a greater degree than dibbling and drilling is *transplantation*. This is done by sowing a small portion of ground with seed early in the season, taking up the plants as they grow, dividing them into single-rooted shoots, and transplanting these. By thus dividing the plants as they tiller, at four periods of the season, a very small quantity of seed will supply as many plants as would cover a large extent of ground. Though wheat no doubt bears transplanting, yet the amount of manual labour which the scheme entails would be so great as to render it impracticable upon any considerable scale. This method, however, has been pursued with a certain measure of success in the formation of permanent pastures.

When it is desired to propagate a new variety of grain quickly, this process of transplanting might perhaps be useful. It may therefore be interesting to preserve the following record of the details and costs of the operation: Suppose 440

[1] Le Couteur's *Wheat Plant*, 29.

grains of wheat are sown widely on the 1st of July, and that every seed germinates by the beginning of August, each seed will afford four plants, or in all,

1,760 plants

At the end of August these will produce . 5,280 "
In September these again 14,080 "
And in November these last will produce . 21,120 "

The time occupied in sowing the 440 grains, and dividing and transplanting their produce, stands thus:—

				Hours.	min.
July sowing,	. . . . .	440 grains,	o		20
August, beginning,	taking up .	440 plants,	o		20
"	dividing into .	1,760	"	1	10
"	planting .	1,760	"	3	30
August, end,	taking up .	1,760	"	1	28
"	dividing into .	5,280	"	3	30
"	planting .	5,280	"	10	33
September,	taking up	5,280	"	4	24
"	dividing into .	14,080	"	9	23
"	planting .	14,080	"	28	9
November,	taking up .	14,080	"	11	44
"	dividing into .	21,120	"	14	4
"	planting .	21,120	"	42	14
				130	49

Equal to 13 days 49 minutes' work at 10 hours a-day. Of these 13 days, 5 days may be reckoned for women and boys occupied in taking up and dividing the plants, which, at 1s. 6d. per day, will cost 7s. 6d. The remaining 8 days are for men transplanting, at 14s. per week, which will cost 18s. 8d. more; both 26s. 2d. per acre. The seed for the plants, ½ bushel at 48s. the quarter, or 6s. the bushel, would cost 3s. The entire cost would be £1, 9s. 2d. The saving of seed from the ordinary quantity sown would be the difference of cost between ½ bushel and 3 bushels, 15s. So that the loss on the transplanting over sowing would be 14s. 2d. Of course the cost of transplanting would vary with the rate of wages.

The best way of executing this plan is to dibble in the seed two grains in a hole, about 4 inches from each other, the plants to be taken up when in a proper state, and divided into five, which would be as many at that time as could be had, and then planted out at once, where they are to remain, thus getting rid of all the intermediate dividings.

GRAIN HARVEST.

The joy of the harvest has been extolled by emotional writers in all ages. The merry whirr of the modern reaper has drowned the dull hum of the primitive "shearing" of ancient times. By the genius of the inventor and the enterprise of the farmer the entire process of harvesting has been revolutionised. Yet with all those changes something of the glory of the harvest still survives. And who would have it otherwise!

Beginning of Harvest.—The nature of the weather during the season has of course much to do with the date of the harvest, as well as with the character of the crop. As a rule, reaping begins with the winter wheat in England in the third or fourth week of July, and about the middle of August in Scotland. Between a late and an early season there may be a difference of three, or even four weeks. The pulse crops follow the cereal crops in ripening.

Stage for Cutting.

The propriety of cutting wheat and oats before they are dead ripe has been so well established as to require no demonstration here. Not only is the yield of grain increased, but the quality of the straw is likewise improved by reaping at this stage.

Loss by too Early Cutting. — On the other hand, wheat, reaped one month before it was ripe, has been found to give an advantage of 22 per cent in weight of straw compared with the ripe, but suffered disadvantage in every other point.

Ripening in the Sheaf.—If there is not too much of the ripening process to be accomplished when the cutting takes place, it will be successfully completed in the sheaf. It is a nice point to decide how much of the ripening may be left till after the grain is severed from the

roots. Experience alone can be relied upon as the guide. There seems little doubt that the cut grain can do more in the way of ripening itself in the sheaf than is generally believed.

Shedding or "Shaking." — One of the greatest risks of loss by allowing grain to become dead ripe before being cut is that of shedding or "shaking." Oats are particularly liable to loss in this way, both by wind and hail storms, before being cut, and by the shedding in the process of harvesting. From 10 to 30 per cent of the corn is often left on the ground in this manner, and the injury is all the greater since it happens that the plumpest and best matured grains are the most easily dislodged from the straw. With oats, therefore, it is especially desirable that early rather than late cutting should be the rule.

The greatest losses by shedding in oats usually take place when high wind follows rain and bright sunshine. After being swollen by the rain the chaff is thrown wide open by the sun, exposing the grain to the play of the wind.

Barley.—The stage at which barley should be cut has to be regulated mainly by the particular purpose for which the grain is intended. If it is to be used for feeding stock, or in the manufacturing of whisky, the crop should be cut just before it is fully ripe. If it is to be employed for brewing, especially for the production of the lighter coloured ales, the crop should be left uncut until it is dead ripe. For brewing, the value of barley depends greatly upon its colour, which, for this purpose, should be as bright as possible, not "steely-white" or gritty-looking, but a pure soft white, with a very slight golden tinge. The deep golden colour so common in barley grown in Scotland and the north of England renders it unfit for the manufacture of light-coloured ales.

To secure this bright colour the barley in the south of England is left uncut until it is dead ripe, when very little drying is sufficient to prepare it for stacking or threshing.

The main object of the farmer who grows brewing barley is to shorten the drying period. While on the root, barley, although drenched with rain, will regain its bright colour to a wonderful extent; but after being cut it is liable to be permanently damaged in colour, even by one heavy shower of rain. The farmer, therefore, not only allows the grain to become dead ripe, but also lets the drying of the straw go on to a considerable extent before cutting the crop.

Happy Medium.—There is a happy medium in the time to begin cutting grain as in most things else. Much will depend upon the district, whether the season be late or early, and the weather good or bad. In late districts, in a backward season, it may be better to cut "on the green side," that is, to begin early, than to delay till the crop is more nearly ripe. In these cases there may be great danger of injury to the crop by inclement weather, perhaps by premature frost and snow, so that the prudent farmer will prefer to have a moderately ripened crop well preserved, than a well-ripened crop injured in the stook.

The exact time when cutting should begin is a matter which each individual farmer must, after careful contemplation, determine for himself every harvest as it comes round.

Ripening Process. — As a general rule, corn in a healthy state comes to maturity first in the ear, and then in the upper part of the straw downwards. When the straw becomes matured first at the root, the grain suffers premature decay; and when this is observed, the crop should be reaped, as it can derive no further benefit from the ground, and its grain will dry more speedily in the stook than on the root.

Judging Ripeness.—The most ready way of judging when the ear is ripe in wheat and oats is to note the state of the chaff in the ear, and two or three inches of the straw under the ear. If these parts are of a uniform straw-yellow colour, and feel hard in the ear of the oat, and prickly in the wheat, on being grasped, they are ripe. On examining the grain itself, it should feel firm under pressure between the finger and thumb, and the neck of the straw should yield no juice on being twisted with the fingers and thumbs.

Barley should be of a uniformly yellow colour in the grain and awns, and the rachis somewhat rigid; and as long as the head moves freely by a shake of the

hand, neither the grain nor the straw is sufficiently ripe.

When very ripe, wheat bends its ear down, opening the chaff, and becomes stiff in the neck of the straw, all clearly indicating that nature intends that the grain shall fall out. Red wheat is less liable to be shaken than white; but any kind will shake out when too ripe, provided the plant is in good health and the grain of good quality,—for it is difficult to make immature grain leave the chaff even when hardened.

Degrees of Ripeness.—It might be supposed that when the ear and the entire straw are of uniformly yellow colour, the plant is no more than ripe; but by that time the straw has ripened to the root, and the ear becomes rigidly bent and ready to cast its seeds with the slightest wind. When the neck of the straw of barley is ripe, it is, as a rule, time to cut; and when too ripe the ear bends down, the awns, diverging, stand nearly at right angles with the rachis, and the whole head is easily snapped off by the wind. In oats, when over-ripe the chaff stands apart from the grain, which is easily shaken out by the wind.

It is not equally prudent to reap all sorts of grain at the same degree of maturity. When wheat is reaped too soon, it is apt to shrink, and have a bluish tint in the sample; and when too ripe, the chaff opens from the grain, which is apt to fall out on the least wind; and some sorts of white wheat are thus very subject to fall out, even before reaching the point of maturity. Barley, when reaped too soon, also shrinks, and assumes a bleached colour. Much less loss attends the reaping of oats too soon than the other grains.

Harvest Labour.

With the use of the self-binding reaper, fewer extra harvest hands are now required than in former times, yet in most cases some additional workers have to be employed in harvest. Farms near a large town may obtain the requisite number daily, and in these cases the labourers usually return to their own homes at night. These extra day-labourers are paid daily or weekly, according to arrangement. On farms at a distance from towns, no reliance can be placed upon obtaining labourers at harvest. For them labourers are hired to remain all the harvest on or near the farm. Such labourers receive food daily, and their money wages are paid at the termination of the engagement.

REAPING APPLIANCES.

Of the many appliances designed for the reaping of the corn crops three alone —the sickle (or hook), the scythe, and the reaping-machine—have been extensively employed. These three came into use in the order named, the first having as yet had the longest lease of life. Except on very small holdings and for odd purposes, the reaping-machine has entirely superseded both the sickle and the scythe, and in its many forms and developments is performing the work in an expeditious, satisfactory, and economical manner.

SICKLE OR "HOOK."

As late as 1868, when the third edition of this work was being prepared for the press, the sickle was considered to be still employed so extensively as to warrant the retention of the detailed account given in former editions of the manner of reaping with the sickle. Since that time, however, the work of the harvest has been completely revolutionised. In most parts the scythe supplanted the sickle, and now the reaping-machine has driven both into disuse.

It is interesting to note that, in several parts of the country, the sickle survived until the reaping-machine was ready to take its place. In these parts the scythe never succeeded in obtaining a footing.

Form of Sickle.—Although the sickle has lost its position as an important farm tool, it will be of interest to reproduce the following notes and illustrations of the two forms, the toothed and the smooth-edged sickles, which were employed.

Toothed Sickle.—The toothed sickle was largely used in former times. It has a blade of iron, with an edging of steel, in which very small teeth are formed (fig. 453).

Smooth-edged Sickle.—The large, smooth-edged sickle, is represented in fig.

454. It has a curvature approaching very near to that which, in this implement, may be termed the *curve of least exertion.* From this circumstance it is an easier implement to cut with than the toothed sickle.

Fig. 453.—*Hook or sickle.*

Sickle still used.—Upon very small holdings the sickle is still in use in many parts of the country. It has this advantage, that women can work it as well as men, while, for the former, the scythe is not a suitable implement. Upon large farms, too, the sickle is sometimes employed in reaping portions of the crop which have been laid and twisted by stormy weather. As late as 1889 large fields in the Lothians of Scotland were on this account reaped by the sickle. It is a tedious and costly process, however, and should be resorted to only where it is impossible to work the reaping-machine or scythe with satisfaction.

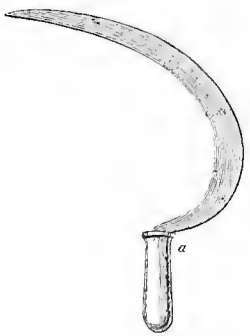


Fig. 454.—*Large smooth-edged sickle.*
a Centre of the handle of the sickle.

Reaping by the sickle requires, of course, a larger supply of hand-labour than either scythe or machine reaping, the latter requiring least of all.

Thraving.—Reapers with the sickle were in most cases paid by piece-work—by so much per *thrave* cut. A thrave consists of two full stooks of corn, each stook of oats and barley consisting of 12 sheaves, and of wheat 14 sheaves, and each sheaf measuring 3 feet in circumference or 12 inches in diameter at the band. The proper size of sheaf was ascertained by a sheaf-gauge, shown in fig. 455. When used, the prong of the gauge embraces the sheaf when lying on the ground, along the band, and if the sides and top of the gauge slip easily down and touch the band, the sheaf is of the required size, the prongs being one foot long and one foot asunder inside.

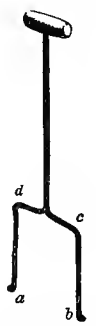


Fig. 455.—*Sheaf-gauge.*
a b c d Prong of gauge.
a b Points of prong.
c d Upper part of prong.

SCYTHE.

The scythe is a more expeditious tool than the sickle. With a given number of men and women, it enabled the farmer to cut down his crop much more speedily than was possible with the sickle. The introduction of the scythe, therefore, led to the general abandonment of the sickle. In certain parts, where there was an abundant supply of cheap labour, the sickle maintained its hold until the overwhelming superiority of the reaping-machine drove it into the limbo of forgotten things.

It is therefore true, though it may seem strange, that in certain districts the scythe was first used to cut "roads" for the reaping-machine.

Hainault Scythe.—Many different forms of the scythe have been employed. The Hainault or Flemish scythe may be regarded as an intermediate implement between the sickle and the cradle-scythe. It is held in the right hand by a handle 14 inches long, supported by the fore-finger, in a leather loop. The blade, 2 feet 3 inches in length, is kept steady in a horizontal position by a flat and projecting part of the handle, 4½ inches long, acting as a shield against the lower part of the wrist. The point of the blade

is a little raised, and the entire edge bevelled upwards to avoid striking the surface of the ground. By fig. 456 an idea of the form of the Hainault scythe and its hook, and of the mode of using them in reaping corn as described, may be formed.

In 1825, the author of this work accompanied the Flemish reapers, Jean B. Dupré and Louis Catteau, through Forfarshire, and drew up a report of their proceedings in that county for the Highland and Agricultural Society. The impression on the farmers present was, that a saving of about one-fourth might be effected by the Hainault scythe in comparison with the common sickle; but it was not equal in its work to our cradle-

Fig. 456.—*Reaping with the Hainault scythe.*

scythe, and therefore never came into general use in this country.

Common Scythe.—The scythes used in this country still exhibit different forms. The helve or sned is usually made of wood, in two short branching arms, as shown in fig. 457, or in one long piece, as in fig. 458.

Cradle.—The cradle-scythe, once very common in the north-east of Scotland, is represented in fig. 457. In this form the scythe-blade is 3 feet 4 inches to 3 feet 6 inches long.

The function of the cradle was to carry the cut corn round with the sweep of the scythe. Except for a very short crop, however, the cradle is really not necessary, and was latterly to a large extent dispensed with.

Setting a Scythe.—In setting the blade, the following rule is observed: When the framed helves are laid flat on a level surface, the point of the blade should be from 18 to 20 inches above

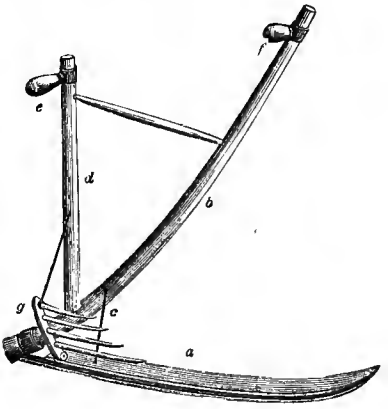


Fig. 457.—*Cradle-scythe for reaping.*

a Scythe-blade.
b Principal or left helve.
d Minor or right helve.
c Grass-nail.
e Right-hand handle.
f Left-hand handle.
g Cradle or rake with its stay.

that surface, and measuring from a point on the left helve, 3 feet distant from the heel of the blade, in a straight line; the

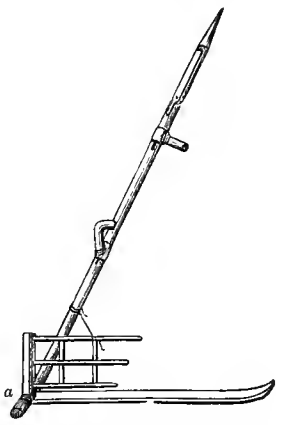


Fig. 458.—*Common reaping-scythe.*

a Cradle.

extremity of the blade should be also 3 feet distant from that point.

Iron Scythes.—Iron has, in many cases, been substituted for wood in the construction of the helves; but it is not

by any means so well adapted to the purpose as the wooden helves.

Straight Sned. — The blade of the common scythe with the straight sned, fig. 458, is mounted on the same principle and the same manner as the blade of the bent sned.

Sharpening Scythes.—When any of the scythes are used in reaping, the strickle and the scythe-stone are much in requisition. They should be used only as often as to keep a keen edge on the blade. Experienced reapers keep a "long" rather than a "short" edge on their scythes, and thus require less of the sharpening tools. An edge put on at a short angle is easily and speedily blunted.

Method of Scythe-reaping.—Reaping with the scythe is best executed by the mowers being placed in *heads*—namely, one head of three scythemen, three gatherers, three bandsters, and one raker; or, as some would prefer, one head of two scythemen, two gatherers, two bandsters, and one raker.

A number of heads on the second arrangement may be employed on a large farm, while a small farm may employ one head on the first arrangement.

Speed with the Scythe.—The speed of the scythe is considerable. A good mower will cut an acre of wheat, or perhaps rather more, in one day; and from one and a half to two acres of oats and barley.

But the almost universal adoption of the reaping-machine has rendered it unnecessary for the present race of farmers to acquaint themselves with the working of either the sickle or the scythe, useful as these appliances have been in their day.

THE REAPING-MACHINE.

In all parts of the United Kingdom, and on almost all farms of any considerable size, the reaping-machine has superseded the slower and older appliances for cutting down the corn crops.

Historical.

Although it did not come into extensive use until near the middle of the nineteenth century, the reaping-machine is by no means a modern invention. It is indeed much older than is generally believed.

Ancient Machine.—Both Pliny and Palladius describe a reaping-machine worked by oxen, which was much used in the extensive, level plains of the Gauls.[1] Pliny's words are: "In the extensive plains of Gaul large hollow machines are employed, with teeth fixed to the forepart, and they are pushed forward on two wheels through the standing corn by an ox yoked to the hind-part; the corn cut off by the teeth falls into the hollow part of the machine."

Nineteenth-Century Machines.—It is known that before the advent of the nineteenth century several attempts had been made to devise a workable reaping-machine. No authentic information has come down to us as to the actual structure of these abortive machines.

But soon after the commencement of the nineteenth century, when agricultural improvements were making progress in every direction, and in particular by the extension of the use of improved machinery to the various branches of farming, active attention was successfully devoted to the invention of a reaping-machine. With the object of stimulating inventors, agricultural societies offered premiums, and we know that within the first twenty-five years of the century nearly a score of reaping-machines, less or more distinct in pattern, and invented by different men, were introduced into public notice in England and Scotland.

The principal of these machines were designed by Boyce, Plunket (London), Gladstone (1806, Castle-Douglas), Salmon (Woburn), Smith (1812, Deanston), Scott (1815, Ormiston, East Lothian), Mann (1820, Raby, Cumberland), and Ogle and Brown (1822, Alnwick).

First Effective Reaping-machine.

It is believed that not one of the early reapers mentioned was ever worked throughout a harvest. Even Smith's and Mann's machines, which were the most perfect, do not appear to have been worked beyond a few hours consecutively. Their actual capabilities, therefore, seem never to have been properly tested.

Bell's Reaping-machine.—The year

[1] *Dic. Gr. and Rom. Anti.*—art. "Agric."

1826 may be held as an era in the history of the reaping-machine, by the invention, and the perfecting as well, of the first really effective mechanical reaper. This invention is due to the Rev. Patrick Bell, minister of the parish of Carmylie in Forfarshire.

The principle on which its cutting operation acts is that of a series of clipping shears (fig. 459). When the machine had been completed, Mr Bell brought it before the Highland and Agricultural Society, who appointed a committee of its members to inspect its operation in the field, and to report. The trials and the report being favourable, the Society awarded the sum of £50 to Mr Bell for his invention, and a correct working-model of the machine was subsequently placed in the Society's Museum—the model, on the closing of that Museum, having been deposited in what is now the Royal Scottish Museum, Chambers Street, Edinburgh. The invention shortly worked its way to a considerable extent in Forfarshire; and in the harvest of 1834, the author of *The Book of the Farm*, in a short tour through that county, saw in operation several of these machines, which did their work in a very satisfactory manner. Dundee appears to have been the principal seat of their manufacture, and from thence they were sent to various parts of the country. It is known, also, that *four* of the machines were sent to the United States of America; and this circumstance renders it highly probable that they became the models from which the numerous so-called inventions of the American reapers have since sprung. At the great fair or exhibition held at New York in 1851, not fewer than six reapers were exhibited, all by different hands, and each claiming to be a special invention; yet, in all of them, the principal feature—the *cutting* apparatus—bears the strongest evidence of having been copied from Bell's machine.

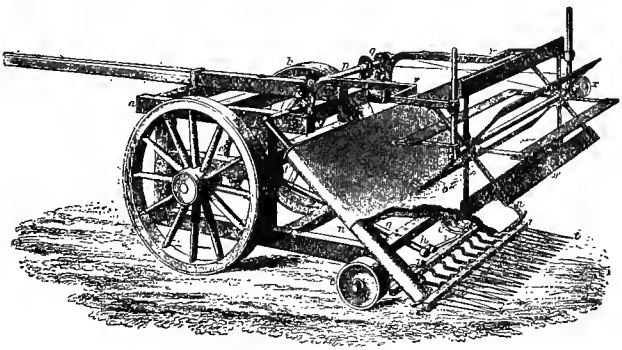


Fig. 459.—*Bell's reaping-machine.*

Construction. — The accompanying illustration, fig. 459, will enable readers to form a just conception of the construction and principles of Bell's machine, and to compare it with the modern implements now in use. The machine was worked by two horses pushing it before them by means of the pole to which they were yoked by the common draught-bar.

Work done.—In the process of working this machine, Mr Bell's practice was to employ one man driving and conducting the machine; eight women to collect the corn into sheaves, and to make bands for these sheaves; four men to bind the sheaves, and two men to set the sheaves up in stooks—in all fourteen labourers, besides the driver of the horses. The work performed averaged 12 imperial acres per day. These data were obtained from fourteen years' experience of the machine, and are therefore reliable.

Cost of Reaping.—The expense in money for reaping by this machine about 1835 averaged 3s. 6d. an acre, including the expense of food to the workers. This, in round numbers, was a saving of one-half the usual expense of reaping by hand, at the lowest calculation; and the saving on a farm where there might be 100 acres of cereal and leguminous crop

would do more than cover the price of a machine of the best quality in two years.

Slow Progress of Bell's Reaper.—It is difficult to account for the fact that Bell's machine was not more extensively adopted. For a period of nearly twenty years it was successfully used; and yet, with practical agriculturists, it did not seem to gain so high a reputation as its American rivals—the machines of Hussey and M'Cormick—yet to be described. It did its work really well, but its draught was exceptionally heavy, and the delivery web was liable to become disordered.

Subsequent makers improved on Bell's machine, and now it exists only as the groundwork of the modern reaper.

American Machines.

The two machines which, perhaps, did most to popularise the reaping-machine in this country were both introduced from America. They were known as Hussey's and M'Cormick's machines—Hussey's being manufactured by Messrs Dray & Co., engineers, of Swan Lane, London Bridge, London; M'Cormick's by Messrs Burgess & Key, Newgate Street, London. These firms introduced great improvements in the machines which they respectively manufactured, so much so, that there would be some difficulty in recognising in them the same machines, the appearance of which, at the Great Exhibition of 1851, created

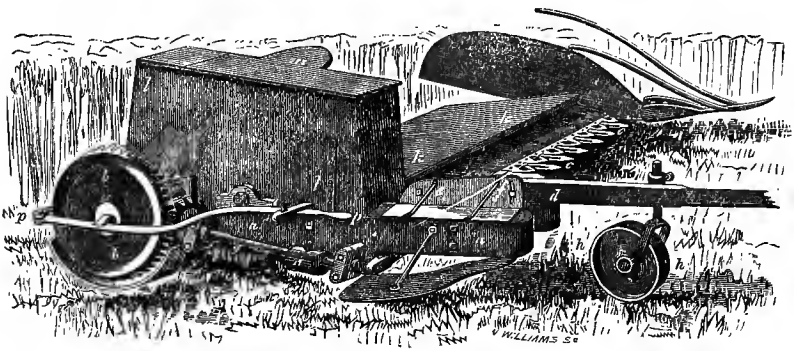


Fig. 460.—*Dray's Hussey reaping-machine in perspective.*

such an interest in the agricultural world.

Dray's Hussey Machine.—In fig. 460 we give a perspective view of Hussey's reaper, improved by Messrs Dray. The cost of this machine was £25.

M'Cormick's Reaping-machine.—In M'Cormick's reaper, with the improvements introduced by Messrs Burgess & Key, Newgate Street, London, the cutting apparatus and driving-gear presented features somewhat similar to those of Hussey's machine. But while in Dray's machine the grain, after being cut, was delivered to a platform, the working of which required a special attendant, and the grain delivered to the ground in quantities sufficient to make a sheaf was required to be immediately bound up in order to clear the path for the return journey of the machine,—in Burgess & Key's the cut grain was at once delivered to a screw platform, and passed to the ground at the side of the machine. A special attendant was therefore not required, and the grain, moreover, being delivered at the side, could be left till the whole could be conveniently bound up.

Modern Reaping-machines.

From these small beginnings in the invention and manufacture of reaping-machines a great industry has sprung up, from which the agriculture of this country has derived benefits of inestimable value. The firms in the United Kingdom who manufacture reaping-machines are now numbered by the hundred, and the larger firms send out several thousand machines every year.

Many improvements have been intro-

duced with the view of simplifying the construction, reducing the draught, lessening the cost, and increasing the efficiency and general usefulness of the machines.

Varieties of Machines.—The reaping-machine is now produced in many forms, less or more distinct, suited for different purposes and different conditions of soil and climate. There are the simple mower, adapted merely for mowing hay and leaving it lying as it is cut; the combined mower and reaper, which may be arranged not only to cut the crop, but also to gather it into sheaves or swathes; the back-delivery, the side-delivery, the self-delivery, and the reaper in which the sheaves are turned off by the hand-rake. And last, and greatest of all, comes the combined reaper and binder, which is now an established success, performing its intricate and difficult work in a most admirable manner.

Draught.—Most reaping-machines are arranged for the draught of two horses. Some may be worked by one horse, and others occasionally require three horses.

Price.—The prices of the different reaping and mowing machines vary greatly, from £13 to £20, according to strength and other features. In recent years there has been a marked reduction in price, and this, accompanied by increased efficiency, has given a great impetus to the employment of machines in cutting the hay and corn crops. The combined reaper and binder costs from £25 to £35.

Perfect Workmanship.—The work accomplished by the leading reapers and mowers is now as nearly perfect as might be. Unless the crop is very seriously laid and twisted, the improved machine will pick it up and cut it from the ground in the most regular and tidy manner, leaving a short even stubble. Now and again a corn crop is laid and twisted by a storm so as to defeat the reaping-machine; but the possibilities of the modern machine are indeed wonderful.

Speed.—The speed of the reaping-machine varies considerably, according to the width and general make of the machine, the character of the ground and the crop, and the horses employed. The extent reaped in a day of ten to twelve hours would perhaps run from 8 to 14 acres, the greatest breadth of course being cut where the machine can work continuously along all sides of the field. This, however, is possible only when the crop stands tolerably erect. If a strong wind is blowing, or if the crop is bent to a considerable extent, it is advisable, to ensure good work, to cut only in one direction—against the "lie" of the crop. The machine in this case returns "empty" and out of gear; and it is not all lost time that is employed in the return journey—for the relaxation is appreciated by and is beneficial to the horses, which can thus go at a smarter pace when reaping and work longer without being fatigued.

Force employed.—The force of labourers required to keep a reaping-machine going varies chiefly with the rate of the reaping and weight of the crop, but partly also with the form of the machine, whether for self or manual delivery. With the self-delivery reaper one man to drive the horses is sufficient on or at the machine. The manual-delivery reaper requires an experienced and careful person to deliver the sheaves, and a man or lad to drive the horses.

To "lift" the sheaves, bind, and stook them, from six to ten persons will be required, according to the rate of reaping and the weight and bulk of the crop. It is the custom in some parts to have boys making bands, women lifting the sheaves on to the bands, and men to bind and stook. In other cases women make bands, lift and bind, the stooking being done by men. In many parts, chiefly in the south of England, men do all the manual harvest-work.

In many cases the raking is now accomplished by a rake attached to the rear of the reaper. When this is not provided the work has to be done by a horse-rake, or by a rake drawn by a man or lad.

Cost of Reaping.—The cost of reaping grain by the reaping-machine, including cutting, binding, stooking (or shocking), and delivery, will vary with the rate of wages, the nature of the ground and the crop, the rate of reaping, and the character of the machine, from about 8s. to 12s. per acre. Much depends upon the season—for it is obvious that when

the crop is standing erect, so that it can be cut continuously around the field, the speed must be greater and the cost less. Then a heavy crop may require one couple more to lift and bind and stook than would suffice for a light crop.

It is well established that, by the introduction of the improved reaping-machine, the work of cutting the grain crops has been not only much accelerated, but also in most cases to some extent lessened in cost.

It is not necessary to describe in detail the mechanism of improved reaping-machines. They are now so simple and efficient that any man of average intelligence and care can work them perfectly. In their general construction there is much similarity. This is indicated by figs. 461 and 462, which represent self-

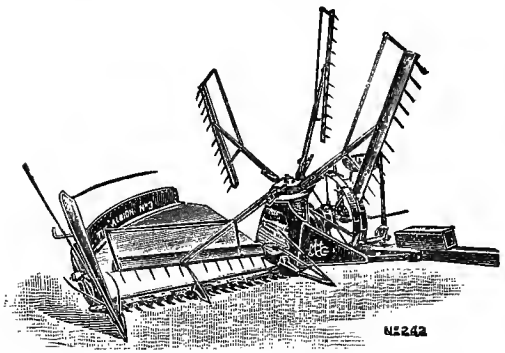


Fig. 461.—*Harrison, M'Gregor, & Co.'s self-delivery reaper.*

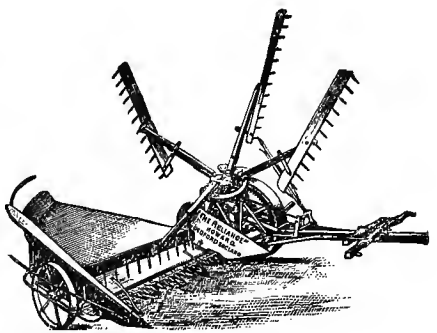


Fig. 462.—*Howard's self-delivery reaper*

delivery reapers made by Harrison, M'Gregor, & Co., and Howard respectively.

Manual and Self-delivery Machines.

Of the two main classes of reaping-machines, manual and self-delivery reapers, the former makes better work with heavy or tangled crops, but requires an extra man in working. In crops which are moderate in length and not much twisted, the self-delivery reaper, with the saving of one man's labour, is quite as efficient as the manual delivery.

Side-delivery Reapers.—Self-delivery reapers are of two classes, back and side delivery. In the former the sheaves are dropped behind the reaper in the same position as those left by the manual delivery, while in the latter they are deposited far enough to the side to permit of the machine passing, whether the sheaves are tied before it comes back again or not. With the side delivery a whole field may be cut without binding any sheaves, while they must be bound as the cutting proceeds if the back delivery or manual machine is used.

In the dry climate of the south and east of England it is often an advantage to cut a crop and let it lie a day or so before binding, hence side-delivery machines are those most in use there.

In Scotland, however, the climate is so uncertain, that a crop cannot advantageously be left unbound even for one day, because should it once get wet when lying loose, the difficulty of drying it again is so great that it more than counterbalances any gain which might result from the method. In Scotland, therefore, the self-delivery reapers are mostly of the back-delivery pattern.

Another point in favour of the system of binding immediately behind the machine is that in this way the labourers work more expeditiously than when they are not pressed by the reaper.

Manual *v.* Self-delivery Reapers.—In districts of Scotland having a moderate rainfall, and where, consequently, the grain crops are moderate or short in the straw, or where labour is comparatively scarce in harvest-time, the back-delivery reaper is the kind most largely used. Indeed, in the eastern counties the back-delivery machine is found everywhere. In the western and south-western coun-

ties, however, a self-delivery reaper is seldom seen, and very seldom do they work well; because in these districts the rainfall is heavy, the straw long and soft, while the whole country is more exposed to wind than on the eastern side of the watershed. The consequence is, that grain crops are usually laid and often much twisted, and in reaping much better work can be done with the manual than the self-delivery reaper.

SELF-BINDER.

The most modern and most expeditious method of harvesting grain is by the automatic combined reaper and binder—one of the most useful agricultural inventions of the nineteenth century.

General Construction. — A sheaf-binding harvester has four separate operations to perform — viz., cutting, elevating, binding, and delivering the crop. In the binder the cutting apparatus differs only in details from the ordinary one-wheeled self-delivery reaper. The grain as cut falls across an endless web, which conveys it over the top of the driving-wheel to the knotter, where the straw falls into two arms called compressor-jaws, which keep it on the knotter-table until a sheaf of any specified size has accumulated. Whenever a sheaf of the desired size has been delivered to the compressors, these relieve the tripper, which sets in motion the needle (carrying the binding twine) and the knotting apparatus. The needle is circular, and in its course it passes the band (twine) round the sheaf, when the band is caught by the knotter, and almost instantaneously a firm and secure knot is tied, while the needle is drawn back ready to operate on a new sheaf. As soon as the knot is tied and the string cut, the sheaf is ejected from the machine in a horizontal position, dropping on the ground on its side, quite clear of the machine.

Efficiency of the Binder. — The binder, as now constructed, is admirably suited for cutting standing grain of any kind, more particularly where the straw is not very long. The land should be laid down with as flat a surface as circumstances will permit, otherwise a longer stubble will be left. Granted a moderate crop of standing grain and good weather, these machines do their work in a way which cannot be equalled in any other manner.

When the binder was first introduced, wire was used in tying. As would be expected, there were strong objections to the wire, and the substitution of twine was a step of the greatest importance.

One drawback to twine is that it is easily cut by mice, and when these vermin get into stacks of twine-bound sheaves, much trouble may be caused by loose sheaves. The best method of prevention is of course to keep mice from getting into the stacks.

THE HORNSBY BINDER.

The binder made by Messrs R. Hornsby & Sons, Limited, Grantham, which won several prizes in important trials, is here described in some detail.

Cutting the Crop.

The cutting apparatus is, as already indicated, similar to that employed in the simple reapers, and need not be particularly described.

The illustration, fig. 463, shows Messrs Hornsby's arrangement of finger and its method of attachment to the framing of

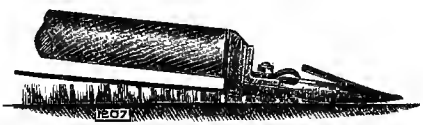


Fig. 463.—*Finger arrangement.*

the machine, by which they obtain the lowest cut without the platform rubbing on the ground. This great advantage is gained by the use of a sheet steel platform, so that the fingers may be close to the ground whilst the platform is quite clear of it.

The platform canvas for carrying the cut crop to the foot of the elevator is kept as low as possible, so that even short crops fall readily upon it without any liability to choke the knife.

The new pattern reel and reel-support can be instantaneously adjusted, up or down, backwards or forwards, for dealing with laid, twisted, or heavy standing crops.

Both inside and outside dividers are made to suit all crops, making perfect division on the one side, and lifting up

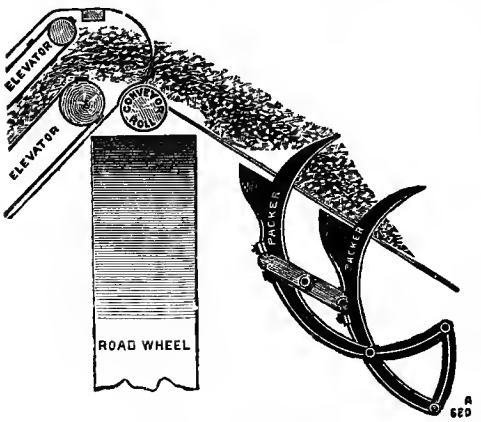


Fig. 464.—*Conveyor-roll.*

hanging ears and cutting every straggling straw on the other.

Elevating.

The cut grain is carried up to the knotter between canvas elevators. These elevating canvases are brought down below the level of the platform canvas, so that the one feeds the other evenly and regularly. This is done by means of a novel arrangement of strengthening plate enabling the canvas rollers to work lower than in any other. The canvases are also shorter, owing to the reduced height of the machine, which, with the increased diameter of the rolls, reduces draught and makes the canvases run perfectly with less frequent tightening and adjusting.

The laths are *riveted to the canvas*, and are of an improved shape, securing easy running over the rollers, and preventing any straws from sticking between them and the canvas.

The canvas rollers run in metallic bearings.

Elevator and Platform Rolls.—By a newly patented arrangement, the rolls for the platform and elevator are made the width of the machine, making the canvases more certain than ever in their action, the roll ends being recessed into the framing, so that loose straws cannot possibly wind round them. The vibrating buttor takes the place of the old canvas buttor, doing away with a considerable amount of friction and lessening the cost of repairs.

Conveyor-roll.—The height of the machine is considerably reduced by the use of a conveyor-roll, to pass the cut crop from the top of the elevators close over the top of the main road-wheel to the binder-table. See fig. 464.

Binding.

The "Hornsby" binding mechanism is exceedingly simple, perfectly automatic in its action, and perfectly reliable in operation.

To avoid wear and save power, the binding apparatus remains at rest, whilst the cut crop in a steady stream passes down from the elevator, and is pressed forward by the packers; but the moment enough has been accumulated to form a sheaf (of one of the five sizes before determined on, according to the crop), the binding mechanism is automatically started, the needle carries the string round the sheaf, the knot is tied, the string cut, the loose end retained for the following sheaf, and the operation is complete.

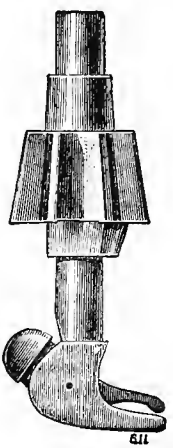


Fig. 465.—*Knotter.*

Needle.—A new patent needle is now used. It works with much less friction on the twine, and is also much easier to thread.

The Knotter.—The improved Hornsby knotter is shown in figs. 465, 466, 467; and fig. 468 shows the manner in which the knot is tied. Fig. 469 represents the tied knot. A bevel gear now actuates the knotter, replacing the old chain mechanism (fig. 470).

Delivery of Sheaf.—It is important that the sheaves should be delivered gently, for if they are subjected to rough usage a considerable quantity of grain might be knocked out, especially if the crop were over-ripe.

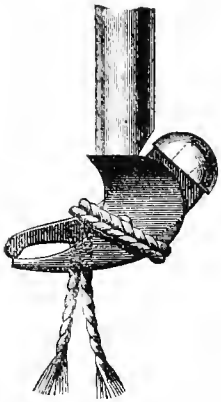


Fig. 466.—*Half turn.*

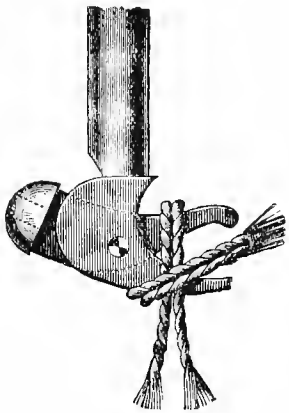


Fig. 467.—*Whole turn, jaws open and string entering.*

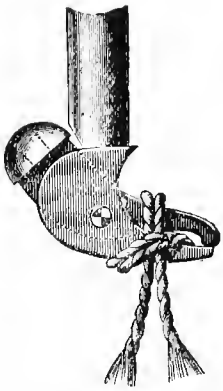


Fig. 468.—*Jaws closed on string; the string-knife then cuts the ends, and the lever draws the string off, completing the knot.*

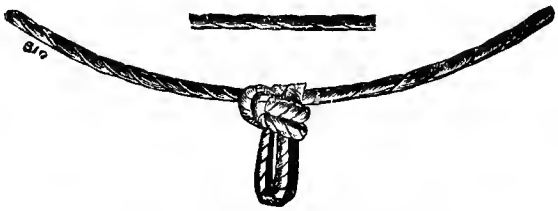


Fig. 469.—*Knot tied by the Hornsby binder.*

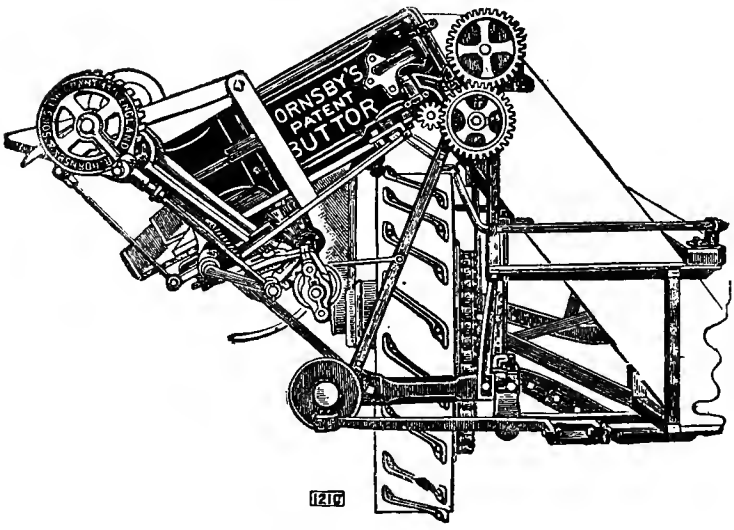


Fig. 470.—*Bevel gear and vibrating buttor.*

In the "Hornsby" binder the sheaf is firmly held whilst the knot is being tied; the ejectors then coming into action press it forward, whilst the retaining boards fall, so as to slide it gently to the ground without liability to shedding. It delivers the sheaf near to the ground, and thus avoids shaking.

At Work.—Roller bearings are freely used for the spindles, and materially lighten the draught. The Hornsby binder may be worked by two good

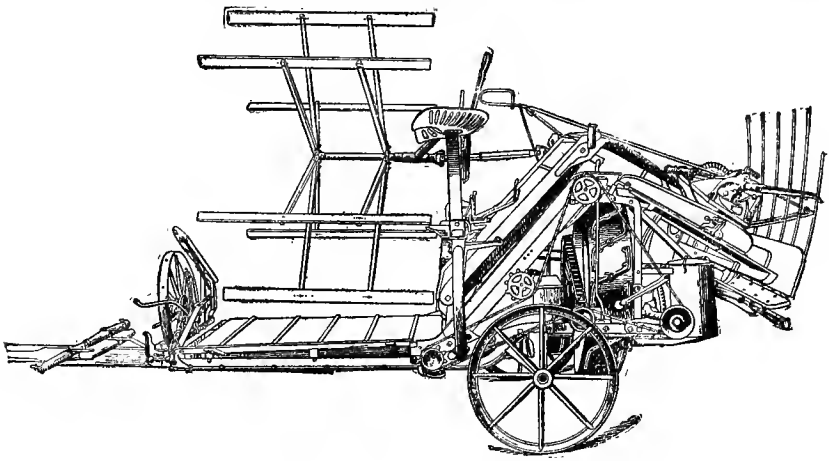


Fig. 471.—*Wood's New Century reaper and binder.*

horses, but many prefer to use three. The horses will perhaps travel about three miles per hour.

Speed.—At this speed and cutting around the field the binder may cut over an acre per hour. Its daily work is therefore a simple question of how many hours it is kept in action.

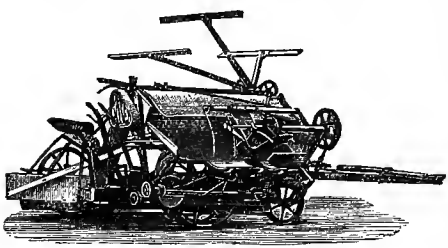


Fig. 472.—*Bisset's binder.*

By laying the sheaves in rows the sheaf-carrier lessens the labour in stooking.

Other Binders.

The manufacture of combined reapers and binders is now carried on extensively by many eminent firms—Canadian and American machines competing strongly against British-made ones in our own country. Each machine has its own peculiar merits and special admirers, but, as with ordinary reapers and mowers, they are now all wonderfully efficient. The other binders best known in this country are the Massey-Harris (Canadian), the Walter A. Wood, the M'Cormick, the Deering, the Plano, the Milwaukee, the Osborne, and the Champion (American). The "New Century Binder," brought out by Walter A. Wood, is represented in fig. 471. Bisset's binder is shown in fig. 472.

Progress of the Binder.

On farms of average size the binder has made more rapid progress, and is a more serviceable machine, than the manual reaper was at its introduction. The experience gained in the manufacture of the ordinary reaper has been fully taken advantage of in the manufacture of the binder; and whereas the first reapers often failed, through the breakage of some more or less important part, the binder rarely does so. When it does fail to do its work, it will, as a rule, be found that the crop is too heavy or too much laid and twisted, or the land unsuitable.

With a light and serviceable binder,

which could be depended on for cutting all average crops, there need be little extra hurry or press of work at harvest more than at any other time of the year, while the whole might be accomplished without an extra hand being engaged.

Working the Binder.

Before beginning with a binder, a couple of swathes should be cut with the scythe round the whole field, or if more convenient, one swathe with a scythe and one with an ordinary manual or self-delivery machine. Two swathes are necessary, not entirely on account of the width of the machine, but to provide walking space for the three horses, often required to work the binder.

Where the circumstances permit, the easiest cut is round the field, but if the crop is bent in any particular direction it must be cut one way only.

Speed in cutting round.—Cutting round about, an acre an hour is easily accomplished, and if the horses travel freely an acre and a half may be done.

Hands required.—According to the weight and closeness of the crop, from two to four men will be required to stook, if going round about, while only half the number will be required if cutting is done one way only. Behind a binder going round the field, a man can stook more grain of an equal weight than he will do after any other method of cutting.

With good string, the knotting apparatus rarely gives trouble, and the whole machine is easily under the control of one man.

Raking.—Where the binder can work anything like satisfactorily, no raking is required, as very few straws are left.

Size of Sheaves.—With a moderately regular crop, the sheaves can be made much smaller than where the crop has to be tied by hand, without adding materially to the cost, the only increase being what extra will be required for binding-twine, and the little additional labour required in stooking a crop of small or moderately sized sheaves instead of large ones.

The small number of hands required in the harvest-field, where a binder is in use, would thus, on a moderate-sized farm, allow of reaping and stacking going on simultaneously—that is, if the varieties of crops were so regulated as to allow them to come forward in regular succession.

Cost of Cutting with Binder and Reaper.

The exact cost of cutting a certain area of corn will of course, as already pointed out, vary considerably in accordance with the kind, condition, and weight of the crop, the configuration of the ground, the rate of wages, and skill in management.

Saving in Labour.—It is now generally conceded that where circumstances are favourable—the fields moderately large and level, and the area under grain crops sufficiently large to warrant the somewhat heavy initial outlay in purchasing a binder,—the cutting can be accomplished at from 1s. to 3s. per acre cheaper by the self-binder than by the ordinary reaping-machine. Common estimates indicate a saving of about 1s. 6d. or 2s. per acre—the saving of course arising in manual labour.

Saving in Crop.—Another point in favour of the binder is that it gathers up the crop more cleanly than the reaper. It leaves fewer stray stalks of grain on the ground, and thus saves both straw and grain. The saving on this head alone has been variously estimated at from 1s. to 5s. per acre. In average circumstances from 1s. to 2s. would perhaps be tolerably near the mark.

Examples of Cost.—Mr John Prout, Sawbridgeworth, Essex, gave the cost of cutting with the binder and the reaper as follows, the extent cut per day being on an average 10 acres by the binder and 12 acres by the reaper:—

Binder.

	£	s.	d.
Six horses	1	10	0
Two men	0	14	0
Two boys	0	7	0
String, 2s. per acre	1	0	0
Oil	0	2	0
Total for 10 acres	3	13	0
Per acre, 7s. 3d.			

Ordinary Reaper.

	£	s.	d.
Four horses	1	0	0
Tying by hand, 6s. per acre	3	12	0
Two men	0	14	0
One boy	0	3	6
Oil	0	2	0
Total for 12 acres	5	11	6
Per acre, 9s. 3d.			

There is here a balance of 2s. per acre in favour of the binder. In many cases the costs with the binder would be less than above by about 1s. per acre.

HARVESTING BY MOTOR.

Only to a small extent as yet have motor tractors displaced horses in working the self-binder and other forms of harvesters. We are still labouring under the disadvantage of having to yoke the motor to machines built for horse draught, and this occasions an unnecessary waste of power, besides the employment of unnecessary labour.

Most likely when we get an actual motor-binder—that is, motor and harvester combined—the wheels of the motor-carriage will be the only travelling wheels, the cutting and binding mechanism being carried on the motor vehicle and doing their work without actually touching the ground.

THE STRIPPER HARVESTER.

In Australia and other large grain-growing countries, where a very small part of the straw is required for the stock-yard, the grain is stripped off and the straw left on the ground, as a rule. Mr M'Kay brought out the first Australian stripper in 1884, but it did not make much progress there until he remodelled his machine in 1894, and produced the first stripper harvester of the now well-known "Sunshine" type. These harvesters are made with varying sized combs, from 5 ft. to 11½ ft. in width, and are said to have reduced the cost of harvesting to less than 2s. 6d. an acre. Compared with the system of cutting, binding, and threshing formerly practised, the introduction of the Sunshine harvester has enabled the farmer to save 12s. or more per acre in harvesting. No wonder that it is now being largely used, not only in Australia, but also in the Argentine and other countries where large tracts of grain have to be harvested, and they can afford to leave the straw on the ground.

In its early form the machine used to strip the heads off, and thresh them, but did not clean the grain, and the winnowing and bagging had to be done by manual labour. The modern harvester combines both the stripper and the winnower, and does the work of both machines at one operation. Drawn by three or four horses, and worked by only one man, it harvests at the rate of about 10 acres a-day, in a crop yielding 20 bushels to the acre; but it is profitable to employ a second man to sew the bags as they are filled, and drop them off the machine, and thereby avoid the stoppages which are necessary where the driver has to stop and lift off the bags.

PROCESS OF REAPING.

The detail-work of reaping corn with the machine varies considerably throughout the country. The process is not quite the same for the different varieties of grain even in any one district, and the climate and labour-customs are also responsible for differences in the methods of working.

Reaping Oats.

The main principles which should guide the farmer in arranging the practical work of reaping are applicable alike to wheat, barley, and oats; yet it will be convenient, in the first place, to describe the reaping of oats, and afterwards point out the distinctions relating to wheat and barley.

Preparing to Cut.—The prudent farmer will have the reaping-machines looked out and put into the pink of condition before the day arrives for the commencement of cutting. Any necessary repairs will have been effected at the end of the previous season. No judicious farmer would think of laying up a machine or implement of any kind for the idle season until the needed repairs have been attended to. It is very bad practice indeed to delay such matters until the time arrives for the active employment of the machine or implement. See that all preliminaries are attended to beforehand, so that when the work of cutting begins there may be no avoidable delay.

Sharp Knives.—Keep the knives as sharp as possible, as good work and light draught cannot be had without sharp knives. Where two or more reapers are

kept going, it is advisable to keep one man sharpening knives, as then they are always in good repair, and cutting goes on more smoothly and rapidly than when the driver has to look after not only his horses but his mower and knives as well.

The most common method of sharpening the knives of reapers is with a fine file supplied for the purpose. Machines for sharpening are now in use to some extent, that made by Harrison, M'Gregor, & Co. being shown in fig. 473.

Cutting "Roads."—A day or two before reaping is to be begun, "roads" for the reaping-machine should be cut with the scythe all round the field or section about to be cut. One cut of the

Fig. 473.—*Reaper knife-sharpener.*

scythe is usually considered sufficiently wide, but at the ends where the machine is to be turned it is more convenient to have the "road" two cuts wide. The corn cut out of the "roads" is tied into sheaves, which are laid against the fence and stooked with the main crop when it is being cut.

The scythe is the most convenient appliance with which to form "roads" for the reaping-machine, but in some parts the hook is still employed for this purpose.

Cutting.—In working with either the manual or self-delivery reaper, cutting may be done in two ways—either along one side of a field or round about. If the crop be not laid in one direction, the weather is moderately calm, and the crop mostly standing, the roundabout method is the best, as no time is lost returning.

Force of Labour.—If the crop is moderately ripe, and the straw dry and free from grass, so that fairly large sheaves may be made, each man binding may do from 3 to 5 roods per day, the extent depending very much on the size of the sheaves, the thickness of the crop, and the tidiness with which the work is done. In many districts of Scotland women do the bulk of the binding; and if the crop is light or the sheaves small, most women who know their work can do as much as the average of men. For heavy crops, however, where large sheaves are made, they are not so well suited, in which cases three women will be required for every two men, or it may even be two women for each man.

In reaping round about, the binders may be distributed in two ways: each may have a certain distance to do, or a certain number of sheaves to tie. If the crop is moderately regular, no better plan need be adopted than that of dividing the circumference of the field into equal divisions for each binder, and sticking a piece of wood into the ground where the one division ends and the other begins. After every half-dozen swathes or so of the reaper, the marking-posts may be moved nearer to the side of the uncut grain, so that disputes may be prevented from arising among the binders as to who should or should not tie certain sheaves. When a binder has finished his or her number of sheaves in a swathe, a stoppage is made until the reaper again comes past, when the work is resumed.

By so doing, all unnecessary travelling backward and forward is done away with, and each binder gets a regular share of the good and bad parts of the crop in the field. In this system of working every one gets an equal share to do, and cannot avoid doing it; yet good as the system is where the binders are all on an equality, it is not a suitable one to adopt where there are inefficient persons or learners, as one slow person in the lot keeps back the whole squad.

The same system can, of course, be pursued where two or three reapers follow each other, if a corresponding number of binders can be obtained. If two

machines are working, the driver of the second should start as soon as the first is half-way round, and the drivers should endeavour to keep as near as possible the half circumference of the field apart. In this system of harvesting each binder should properly clean up the ground where each sheaf has been made, before leaving the spot.

Raking.—A drag-rake similar to a hay-rake, but smaller, is often attached to each machine, which rakes the ground that was cut the swathe previous. In order to allow the rake to work, the sheaves as tied are in some cases conveyed back from the standing grain fully two breadths of the reaper. The necessity for this is averted by each binder letting his sheaves lie just clear of the last swathe,—that is, where the binding and stooking are done by different men,—a plan which is largely followed.

Other Methods.—Various other methods are followed. By one method in which each binder has an equal number of sheaves, each begins near or where they ended the time previously, the number of sheaves, not the distance, regulating the place. This system is very well suited for comparatively small fields where the number of sheaves allotted to each binder is not very large, no larger than each binder can easily count his or her own share without moving backward to do so.

Detecting Bad Work.—Another advantage is that by this method each binder's sheaves are all together, so that the farmer can at once see if any one has been doing the work in a careless or slovenly manner; whereas by any of the other methods, it is impossible to say by whom the sheaves were bound and stooked after the first or second swathe.

Arranging the Force for Manual-delivery Reapers.—Where the cutting is round about, binding behind the manual-delivery reaper is the same as if a side or back-delivery machine were used. Most of the cutting with the manual-delivery machine is, however, done only along one side or end of a field. In this case the binders may have an equal or any number of sheaves each, or a certain distance.

If two manual-delivery machines are working together, the one should be just entering the swathe while the other is going out at the other end, so as to allow the binders an equal time to tie the sheaves behind each machine.

In some cases it has been the custom to have the band-making and lifting done by women and lads, and with men following to bind and stook. It is more expeditious, however, for each labourer to combine the lifting and binding, and leave the stooking or shocking to another. One man can stook to four or five lifting and binding, one known to be an expert at stooking being entrusted with this work.

Bands and Binding.

The corn-band, fig. 474, is made by taking a handful of corn, dividing it into two parts, laying the corn-ends of the straw across each other, and twisting them round so that the ears shall lie above the twist—the twist acting as a

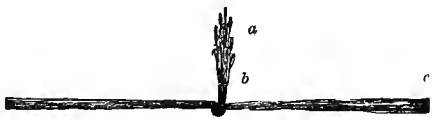


Fig. 474.—*Corn-band ready to receive the sheaf.*
a Corn-end of straw. *b* Twisted knot.
c c Band stretched out.

knot, making the band firm. The lifter then lays the band stretched at length upon the ground, to receive the corn with the ears of the band and of the sheaf away from him.

The bands should always be made of two lengths of straw, as under no circumstances can a single length be used advantageously.

Method of Binding.—In approaching the sheaf the binder gathers the spread corn on either side into the middle of the band with both hands, and, taking a hold of the band in each hand near the ends, he crosses the ends of the band, pulls forcibly with the right hand close to the sheaf, and keeps the purchase thus obtained with the under side of the left hand, while he carries the end in the right hand, below and behind his left hand; and then, taking both ends in both hands, twists them firmly and thrusts the twist under the band with the right hand, as far as to keep a firm hold. In a bound sheaf, the corn-knot

in the middle of the band is held firm by the pressure of the sheaf against the ears of corn and the twisted part of the band.

Position of the Band. — The band should always be put on as near the middle of the sheaf as possible, never below the middle, but if anything above it. If put on much below the middle the top of the sheaf spreads out, instead of keeping close together, and if rain comes on the water runs down the centre of the sheaf instead of the outside of it.

Size of Sheaves.

Although large sheaves add considerably to the speed with which a crop can be tied, they hinder materially the after-drying of the crop. In the end it will therefore be found the most profitable way to make the sheaves as small as possible, consistent with the length of the crop. In a short crop with grass among the straw, they should not be over 6 inches in diameter at the band, and in the longest and cleanest straw 10 inches will be quite sufficient.

Lifting broken Stalks.—If the crop is much twisted or tangled, a young lad is often employed with a fork to raise up the heads of the standing grain, should these be inclined to be broken down by the passage of the reaper. It is advisable to have this done, because if the ears are not lifted up they are liable to be cut off by the next passage of the machine, and left on the ground instead of being secured in the sheaf.

Raking.

With the use of reaping-machines there is much less of the crop to be gathered from the ground in the form of rakings than when the scythe was used, and this is one of the advantages of the changes in harvest operations.

A hand-rake of a type long in use is shown in fig. 475. Although this is commonly called a hand-rake, it is really pulled by a leather strap, attached to the shaft and passed over the shoulder of the raker.

If the machines are cutting only one way, in returning they must pass behind the second row of stooks, in order to give the raker time to rake the space between the first and second rows.

Drying Rakings.—The disposal of rakings during harvest operations has been a difficulty with many people. Some farmers maintain that the best, least costly, and easiest way is for the raker to thrust each lot as gathered into the very centre of a stook; but a better plan is to tie them into sheaves, and set the sheaves together in threes and fours. They should be thrust as far in as to be clear of the end pair of sheaves. In this position they will be free from rain; and owing to the current of air through the stook they dry quickly, and at stacking time they can either be brought in along with the sheaves or by themselves.

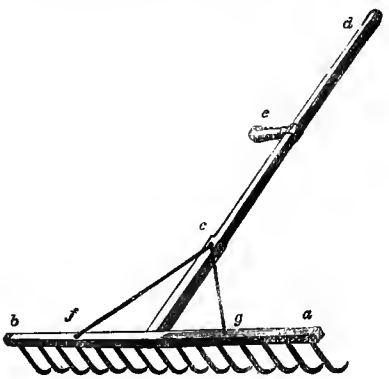


Fig. 475.—*Hand stubble-rake.*

a b Head of rake. *e* Handle.
c d Helve. *f c g* Iron braces.

Others, however, object to this plan, on the ground that the rakings placed in the centre of the stook interfere with the drying of the crop.

Stooking or Shocking.

Where the reaper is cutting one way only, two stookers or shockers will be required. If two machines are working together, three will be sufficient in a short-strawed crop, while four may be hard enough worked in a long crop. Shocking or stooking should always begin at the end of the swathe which is first cut, the second stooker beginning a new row as soon as he sees the first one started, and the others as soon as possible afterwards, each beginning as near as possible about the same distance from the standing grain. An easy guide is for all to follow some particular wheel-

track of the reaper, as these in most circumstances are easily seen.

Stooking. — In setting a stook, the centre pair of sheaves should always be set up first. Each sheaf should get a good solid dump on its butt end, so as to give it a firm foundation; and the two sheaves should be firmly pressed together at the top, by putting a hand on the outside of each a little above the bands, and exerting considerable pressure on these parts. Each following pair of sheaves should be put at opposite ends of the stook, in such a position that they only very slightly incline their heads towards the centre of the stook.

It is sometimes said that in stooking, each pair of sheaves should stand perpendicularly or independently of the rest of the stook. Such instructions are decidedly wrong, and should not be followed in practice. If the first pair are perpendicular, and all the other pairs have a very slight lean towards the centre pair, a much more substantial stook is built than if all are set perpendicularly.

Direction of Stooks.—The direction to which the ends of stooks point is a very important one, to which, in many cases, too little attention is often paid. When finished, the stooks should always point as nearly as possible between south and south-west—to the one o'clock sun—as the prevailing winds then strike them on the end, and blow right through the stook. In this direction the sun dries each side of the stook about equally, which, in a wet or late harvest, is a matter of considerable importance.

Placing the Band-knots.—Were the corn-knots in the bands set outwards in the stook, the rain in a wet season might injure them; and as they bear a sensible proportion to the corn of the whole stook, the sample might thus be materially injured. By simply turning the corn-knots inwards and the root-knots outwards, the injury is prevented. In a fine season the corn-knots may be placed outside.

But in the hood-sheaves the corn-knots were generally placed uppermost, and exposed to the rain; because, were the other *side* of the sheaf exposed *upwards*, where a groove runs down the length of the sheaf, by the straw being gathered into that form while making the root-knot of the band, the rain might penetrate by the groove through the body of the sheaf, lying in its horizontal position, to the corn in the standing sheaves below, and thereby inflict a much greater injury than merely spoiling the corn-knots.

Size of Stooks.—In no variety of harvesting work is there greater variation than in that of shocking or stooking, simple and plain as it may appear to be. In some districts the sheaves are entirely set up in stooks of four or six sheaves, while in others they will be found of all sizes, up to fourteen or sixteen pairs of sheaves. By making extremely long stooks, the risk of their being blown down by the wind is undoubtedly lessened, but at the same time so is the speed with which they are dried. In a large stook the end pair of sheaves will usually be found ready to stack several days before any of the centre pairs; and if any of the centre pairs get soaked with rain, they will scarcely dry at all, unless taken from the centre.

If the grain is not very tall, fine in the straw, and contains any rye-grass or other grass, the stooks should not, as a rule, be larger than eight sheaves, four on each side, and in sheltered situations the number may be advantageously reduced to six sheaves. Very short-strawed crops should also be set up in stooks of four or six sheaves, or in exposed situations eight sheaves may be used. Where the straw is full length, eight sheaves are most generally used, and if the crop is very long, the stooks may contain ten or twelve sheaves.

"Pirling."—A plan of stooking sometimes pursued in certain exposed districts of the west and south-west is to set up two pairs of sheaves, the one pair at right angles to the other instead of side by side, as in an ordinary stook. The butts of the sheaves are if anything kept a little wider apart than in ordinary stooking, and when set up, the tops of the four sheaves are tied together about 9 inches under the apex, by a few straws pulled out of the top. This system is called "pirling," and, unless in particular districts, was probably more common half a century ago than now.

Stooks of this class dry much quicker than those of any other, and withstand a gale which levels almost all other stooks. The time required to do the

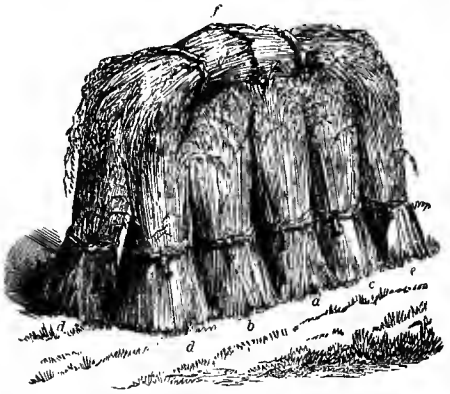


Fig. 476.—*Barley or oat stook hooded.*

a First 2 sheaves set. *b* Second 2 sheaves set. *c* Third 2 sheaves set. *d d* Fourth 2 sheaves set. *e* Fifth 2 sheaves set. *f* Hood-sheaves set.

extra tying, although a little, is not great, and need not deter any one from adopting it, where the circumstances call for such protection from wind and rain.

Hooding.—The use of hood-sheaves for oats, although at one time almost universally adopted, is now seldom resorted to. Owing to the earlier and shorter harvest of the present as compared with bygone times, some of the precautions once adopted are not now necessary.

A once common form of "hooding" is shown in fig. 476.

"Gaiting."—Another ancient method of setting up sheaves, which has now almost entirely been discarded, is "gaiting"—viz., setting up each sheaf singly, where the grain was wet when cut. The band of the sheaf is tied loosely round the straw, just under the corn, fig. 477, and the lower part of the sheaf is made to stand by spreading out the straws' end in a circular form. Gaitins are set by the bandster upon every ridge; the wind whistles and the rain passes through them. Gaiting is practised only in wet weather, and even then only when a ripe crop is endangered in standing by a shaking wind. It is used for oats and barley, wheat never being gaited, because when wheat gets dry, after being cut in a wet state, it is apt to shake out in binding the gaitins.

Reaping Barley.

In nearly all respects the harvesting of barley is much the same as that of oats. Barley, however, as has already been indicated, is rarely cut with a green tint like oats, but is allowed to stand till it is fully ripe, more particularly if it is intended for malting purposes. For malting it must all germinate at or near the one time, and if a portion of the grain is not fully ripe when cut, these grains will be more tardy in germinating.

Quick Drying.—As bright clear samples are of most value for malting purposes, those samples giving a price very much in excess of darkened ones, it is of great importance to a farmer to be able to shorten the period during which his barley crop runs risk of damage from the weather.

Small Sheaves.—Small sheaves, owing to their being quickly dried to the very centre, and a much larger proportion of the grain being exposed to the influ-

Fig. 477.—*Gaitin of oats.*

a Band loosely tied. *b* to *c* Base of sheaf spread out.

ence of the sun and air, are much to be preferred to large ones, as the latter are apt to darken the grain in the centre of the sheaf. In an unsettled harvest large sheaves can scarcely be got dried through, whereas had they been small,

they might have been at least so far dried as to be rickled, where the drying can be completed without much further risk.

A larger proportion of barley than any other grain is threshed from the stook, and small sheaves and stooks are as great an advantage for such in good bright weather as in times when it is dull and close.

Stooks of barley are occasionally "hooded."

Reaping Wheat.

Scythe unsuitable.—In the cutting of wheat the scythe has never been extensively used. The straw of wheat is so hard that the scythe does not readily cut it, and when cut by the scythe it is almost impossible to make a respectable sheaf of it. Scythe-cut sheaves of wheat are generally very long, a great many ears are in the butt of the sheaf, and the stooks rarely ever stand well, even when carefully put up.

Reaping-machines.—The ordinary self and manual delivery reapers all make excellent work in a wheat crop, and were suitable for harvesting wheat before they could be generally used for the softer-strawed grains.

Self-binders.—In a regular up-standing crop of wheat no class of machine can do work equal to the binder, and at so small a cost. In wheat of the proper class the binder's highest degree of perfection is attained, and harvesting is done by it with an ease, speed, and accuracy of which, before the days of binders, farmers could have formed no conception.

Time to Cut Wheat.—Wheat should not be so ripe as barley when cut, but riper than was suggested for oats. Whenever wheat becomes white or yellowish-white under the ear, it may be cut any time, as no more sap can then pass from the lower portions of the straw, much less from the roots, to the ear. If cut rather on the early side, the outer skin or brawn is generally thinner and clearer; while if the crop is allowed to become dead ripe, the colour is deadened or dulled, while the outer skin is much thickened. This thickening of the outer skin apparently is a provision of nature to prevent premature decay of the grain. Extra ripe wheat also germinates freely if subjected to rough weather; and although early and strong germination is a good point in a seed sample, it is rather a bad one when it occurs in the stook.

Sheaves for Wheat.—Owing to the dryness, stiffness, and length of the straw of wheat, it is usually advisable to bind it in larger sheaves than any of the other classes of grain. A large sheaf of wheat dries about as easy as a small one of oats or barley; and whereas oats or barley are easily stooked if small sheaves are made, it is difficult to satisfactorily put up stooks of small sheaves of wheat. The straw of wheat is so hard and slippery that small sheaves easily slide past one another, and even in calm weather they are difficult to keep on end, and in stormy weather they are almost sure to go down entirely.

Wheat Stooks.—Stooks of wheat are most frequently built of ten or twelve sheaves. Small stooks of wheat, such as have been recommended for oats, are liable to be thrown over by wind.

Hooding.—Before the advent of the reaping-machine, it was customary to cover each stook of wheat with two hood-sheaves, as shown in fig. 476. For wheat these were tied as near as possible to the butt-end, and were laid along the top of the stook, the two butts meeting above the centre. Both hood-sheaves were laid on at a considerable angle, generally about half the slope of an ordinary roof.

When put on, the first hood-sheaf should cover fully one-half the stook, and when the other one is put on, the butt-end of the first one should be slightly pushed up. After fixing the second one similarly to the first, the workman steps to the side of the stook and carefully presses the two butts into each other.

The hood-sheaf on the east side should always be put on first, as the butt of the west one shelters it from the west wind, and prevents it from being thrown off.

Hooded in this manner, wheat stooks stand a considerable amount of either wind or rain; but if carelessly done it is worse than useless, as the first gust of wind knocks a large proportion of the hoods off, and if rain falls, both hood-sheaves and stooks are worse wetted than if they had not been hooded at all.

STACKING CEREALS.

The reaped corn must be allowed to remain some time in the stook in the field in order that it may become sufficiently dry to keep in the large quantity composing a stack.

Time for Drying.—The length of time required for drying depends largely on the weather, but partly also on the ripeness of the corn when reaped. If the air is dry, sharp, and windy, the corn will be ready in the shortest, while in close, misty, damp air, it will require the longest time. At least one week for wheat, and 10 days for barley and oats, will usually be required. Small sheaves of course dry more quickly than large sheaves. Corn having an admixture of grass in the ends of the sheaves is the most difficult to dry. In reaping with the machine the corn is more closely packed in the sheaf than when reaped with the scythe, and thus in the former case a day or two's longer drying may be required.

Judging of Dryness.—Mere dryness of straw in feeling does not constitute every requisite for making newly cut corn keep in the stack. The natural sap of the plant must not only be evaporated from the outside, but from the inside also. The outside may feel quite dry, whilst the interior may be moist with sap. The state of the internal condition, therefore, constitutes the whole difficulty of judging whether or not corn will keep in the stack.

Several criteria exist by which certainty is arrived at—namely, by the straws being loose in the sheaf; by easily yielding to the pressure of the fingers; by the entire sheaf feeling light when lifted off the ground, and dry when the hand is thrust in beyond the band; or by twisting a straw, and observing if any sap remains in it.

Weather and Drying.—Winning is effectual when the weather is dry. Wind is also winning, but the stooks are apt to be blown down, which incurs the trouble of setting them again. Rain immediately following or accompanying wind injures stooks materially. When much rain falls, accompanied with cold, the corn becomes sooner ready than the straw for the stack; and, to win the straw, the bands may have to be loosened, and the sheaf spread out to dry in the wind and sun. In like manner, the sheaf may be spread out in dry weather, when a large proportion of young grass is mixed with the straw.

Corn wins in no way so quickly as when "gaitined" (fig. 477).

Sprouting.—When the air is calm, dull, damp, and warm, every species of corn is apt to sprout in the stook before it is ready for the stack. In this way the quality of the grain is often much injured.

Process of Stacking.

Temporary Stacking or "Rickling."—Oats which have had rye-grass, clovers, or other grasses sown with them are usually difficult to dry, and more particularly in a damp climate or a late season. With such crops "rickling," "coling," or "hooacking" is sometimes resorted to before the crop is dry enough for stacking. A "rickle," "cole," or "hooack" may contain from 6 to 8 or more stooks, according to the size of the stooks and length of the crop.

The centre of the "rickle" is composed of 4 or 6 sheaves, all set up together, with the bottoms slightly out and the heads close together. Around these are built another circle, the butts of which also rest on the ground, the next row being kept far enough up to just cover the straps or bands of the sheaves of the preceding one.

Advantages of "Rickling."—This manner of securing a crop allows of the butts of the sheaves being dried in a way attained by no other system.

Sheaves with grass in the butts very speedily kill off the young grasses under them, particularly in wet weather. "Rickling" allows of the crop being placed in a new position, and damage to the grasses avoided, while at the same time almost securing the crop, and putting it into such a position that it readily dries afterwards, and is seldom difficult to get dry enough for carting to the stack.

Preparing for Stacking.—Prior to harvest the stackyard should be put in order to receive the new crop by removing everything that ought not to be in it

—such as old decayed straw; and weeds, such as strong burdocks, thick common docks, tall nettles, rank grass, yellow weed; which in too many instances are allowed to grow and shed their seeds, and accumulate to a shameful degree during summer. The larger classes of implements are often accommodated in the stackyard for want of sheds to keep them in, and these must now be removed.

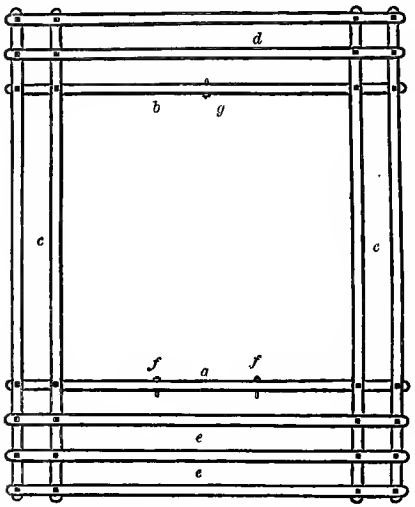


Fig. 478.—*Corn and hay cart tops or frame.*

a Foremost main bearer.
b Hindmost main bearer.
c c Pairs of slight side-rails.
d 2 hind cross-rails.
e e 3 arched fore cross-rails.
f f Bolts through rail in front of cart.
g Bolt through rail on backboard of cart.

Where stathels are used, they should be put in repair. Loose clean straw should be built in a small stack on one of the stathels, or other place, to be ready to make the bottomings of stacks as wanted. Drawn straw or other thatch material should be ready for thatching the stacks as they are built, in case of wet weather occurring—a little time being given for the stack to settle, else the ropes by which the thatch is held become loose, and require to be tightened.

Straw-ropes or coir yarn should be stored in the hay-house or elsewhere, ready to be used in thatching. New straw, being less brittle, is better suited than old straw for making into ropes. For this purpose a few loads of sheaves can be threshed early, even though only partially dry. The tops or frames should be put on the tilt-carts; the corn-carts should be put on their wheels and the axles greased; and the ropes should be attached to the carts. The forks for pitching the corn in the field, and from the carts to the stacks, should be ready for use. Neglect and want of foresight in these particulars, small as they may appear, indicate mismanagement on the part of the farmer.

Cart Frames.—The tops or frames for placing upon tilt-carts are a light rectangular piece of framework, as shown in fig. 478. Two main bearers are fitted to lie across the shelvements of the cart; the foremost is slightly notched, and the hindmost rests against the backboard of the cart, the top sides of which are first taken off. One pair of slight side-rails is applied on each side, crossing the bearers, and notched upon and bolted to them with screw-bolts, these being crossed by two rails behind, and by three more in front; and as these last project over the back of the horse, they are made in arch form, fig. 479, to give freedom to the animal.

A simple and effective method of securing the frame to the cart is by means of the bolts in the bearers, the front ones passing through the head-rail of the front of the cart, and the hind one through the top-rail of the tail-board.

Harvest Cart.—But the common corn or hay cart is a more convenient and efficient vehicle for carrying the corn crops into the stackyard than the tilt-cart with the frame, inasmuch as the load is more on a level with the horse-draught, and the body being dormant, the load is not liable to shake with the motion of the horse. Fig. 480 gives a perspective view of such a cart. Lightness is a special object in its construction, so that it is made of light strong wood.

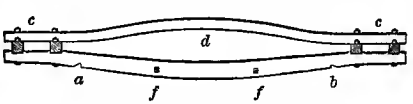


Fig. 479.—*Transverse section of the tops or frame.*

a b Notches in foremost main bearer.
c d c Arched rails over back of horse.
f f Bolt-holes in frame.

Corn-carts are not in all cases furnished

with wheels of their own. The body may be set upon those belonging to the tilt-carts. The cart weighs about 8 cwt.

It is easily converted into a *dray-cart* by simply removing the framework, which should then have the standards based upon two longitudinal rails, instead of being mortised into the shafts. In such a form it is eminently useful in carrying large timber.

Farm Waggon.—The English farm waggon is often preferred in carting corn, especially where the distance from the field to the stackyard is considerable.

Harvest Forks.—Forks used in the loading of corn require to have long shafts, not less than 6 feet, and small prongs. Such a length of shaft is required to lift the sheaf from the ground to the top of a loaded cart, or from the cart to the top of a stack. The fork used in the field should have a strong stiff shaft, as the load on the cart is at no great elevation. That for unloading the cart to the stack should be slender and elastic, as many of the sheaves have to be thrown a considerable height above the head.

The prongs, being small (about half the length of the prongs of the hay-fork), just retain hold of the sheaf, without being so deeply pierced into the band as to be withdrawn from it with difficulty. A deep and firm hold with long prongs renders the pitching of a

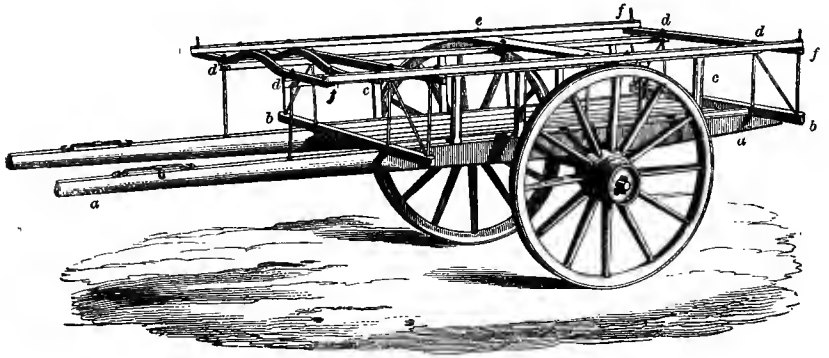


Fig. 480.—*Common corn and hay cart.*

a a Shafts of Baltic fir. *c c* Oak standards. *e* Broad load-tree.
b b Cross-heads. *d d*, *d d* Inner top-rails. *f f*, *f f* Outer rails, front and rear.

sheaf a difficult matter; and if one of the prongs happens to be bent, or a little turned up at the point, the difficulty is much increased.

The prongs of the forks are now made of steel, and are therefore much lighter, more durable, and far superior in every way to the old-fashioned iron fork.

The best fork for the person on the top of the stack to use, in assisting the builder, is the short stable-fork.

Cart-ropes.—The loads of corn and hay on the carts are fastened with ropes, which should be made of the best hemp, soft and pliable. Ropes are either single or double, and both are required on the farm. Double cart-ropes are from 20 to 24 yards long, and single ones half those lengths.

Fig. 481 shows the rope coiled and suspended when not in use.

Care of Ropes.—Cart-ropes last according to the care bestowed on them. When used with the corn-cart, they should never be allowed to touch the ground, as earthy matter, of whatever kind, soon causes them to rot. When wetted by rain they should be hung out in the air to dry. On being loosened when the load of corn is to be delivered to the stacker, they should be coiled up before the load is disposed of, and not allowed to lie on the ground till the cart is unloaded.

A soft rope holds more firmly, is more easily handled, and far less apt to crack, than a hard one.

Forking.—The carts, forks, straw, and

ropes being in readiness at the steading, and the corn fit for carrying to the stack-yard, the first thing is to provide an efficient person to fork the corn in the field to the carts. That man is the best for this work who is able to wield the sheaves from each stook with ease, and has dexterity to place them in positions most convenient for the carter to build them on the cart. Throwing the sheaves in an indiscriminate manner, or too quickly upon the cart, makes the work less easy for the carter; for he has the trouble of turning the sheaves to arrange

Fig. 481.—*Coiled-up cart-rope.*

them aright, while his footing upon the load is insecure. A delay of two or three minutes thus occasioned in loading each cart makes a considerable loss of time upon the day's work.

Injury to Young Grass.—In carrying the crop off the ground, care should be taken to do as little injury as possible to the land with the cart-wheels, particularly to young grass. If the track is frequently changed little damage will be done.

Order in Forking Sheaves.—In forking a hooded stook from the ground, the hood-sheaves are first taken, then the sheaves from the body of the stook, from one end, sheaf by sheaf, in pairs, to the other end.

When stooks have stood long upon the ground, they may require considerable force to remove them.

Carting "Gaitins."—On removing gaitins from the field, they must first be bound into sheaves, which is done by loosening the slack band from its tying and slipping it down the body of the gaitin to the proper place, and binding it in the manner of a sheaf when reaped. They are not stooked when bound, nor left scattered on the ridges as they stood before, but laid in heaps on alternate ridges with the corn-ends away from the cart, as near the furrow-brow as most convenient for the forker and the carter. A number of hands are required to bind gaitins as fast as they are carted off.

Loading a Cart.—A corn-cart is loaded with sheaves in this way: The body is first filled with sheaves, their butt-ends to the shaft-horse, and to the back-end of the cart. When these come to the level of the frame, other sheaves are placed across them in a row along both sides and both ends of the frame, with the butt-ends projecting as far beyond the outer rail as the band. Another row of sheaves is placed upon these. Sheaves are then placed along the middle of the cart with the butt-ends like those in the body upon the corn-ends of the side sheaves to fill up the hollow of the load.

Thus row after row of sheaves is placed, and the hollow in the middle filled well up at last, 12 full stooks making a good load upon an ordinary cart.

Before finishing, it should be seen that the load is neither too light nor too heavy upon the horse's back.

A load thus built will have all the butt-ends of the sheaves on the outside, and the corn-ends in the inside.

Roping Loaded Carts.—The ropes keep the load from jolting off the cart upon the field and the road. They are thrown across the load diagonally from the hind part of the cart to the opposite shaft at the front, and one end is made fast to each shaft, the forker holding on the slack, while the carter on the load tightens the rope by pulling from behind, and tramping on the sheaves to make them firm. The crossing of the ropes at the centre prevents the load splitting asunder over each side of the cart.

Hours of Carting.—Carrying often is continued from break of day to twilight. From a little after sunrise to a little

after sunset, corn may be taken in with safety. Morning and evening dew may occasionally interrupt the carrying.

Commencing Stack-building.—While the first cart has gone to the field, the builder of the stacks, or stacker, collects his forks, ladders, and trimmer; and his assistant, who pitches the sheaves conveniently for him on the stack, fetches a few straw-ropes and a hand-rake into the stackyard.

The first stacks are built on the stathels, which are arranged along the fence of the stackyard, and which require no preparation for the reception of the stacks.

When more than one stacker is required, each should have one head of carts leading to him; and the number of carts in one head depends on the distance the corn has to be brought. There cannot be fewer than two carts to one head, to come and go. The same forker and carts should serve the same stacker, because the same workers together understand each other better in their work.

Arranging a Stackyard.—In filling a stackyard, the barley being the first crop threshed—being the first in demand in the market—their stacks should be placed nearest the barn; and wheat being last threshed, their stacks are placed upon the stathels. Oats being required at all seasons, their stacks may be placed anywhere.

Stacks of peas and beans fill up the heart of the stackyard when there is room, or are placed on the outside.

Foundation for Stacks.—When stacks are built upon the ground, stools of loose straw or other material are made, to prevent the sheaves at the bottom receiving injury from the dampness of the ground. A stool for a stack is made in this manner: Stick a fork in the ground, on the spot where the centre of the stack is desired to stand. Put a quantity of dry straw round the fork, shake it up with a fork and spread it equally thick over the area the stack shall occupy. Then take a long fork, with the radius of the stack notched upon its shaft, 7½ feet; embrace the shaft of the upright fork between its prongs, and in walking round push in or pull out the straw with a foot, so as to form a circle having a diameter twice the radius notched upon the shaft of the fork (fig. 482).

Process of Stack-building.—In setting a loaded cart to a stack, the carter should take advantage of the wind in forking the sheaves from the cart. The stack should be built in this way: Set up a couple of sheaves leaning on each other in the centre of the stathel, and another couple against their sides. Place other sheaves against these in rows round the centre, with a slope towards the circumference of the stathel, each row being placed half the length of the sheaf beyond the inner one, till the circumference is completed, when it should be examined; and where any sheaf presses too hard upon another, it should be relieved, and where a slackness is found, a sheaf should be introduced. Keeping the circumference of the stack on the left hand, the stacker lays the sheaves upon the outside row round the stack, placing each sheaf with his hands upon the hollow or intermediate space between two of the sheaves laid in the preceding row, close to the last one, and pressing it with both his knees (fig. 483)

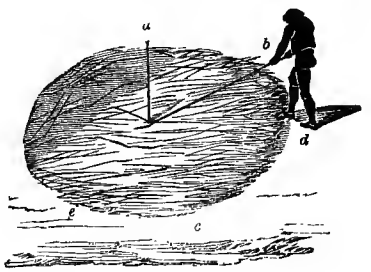


Fig. 482.—*Making a stool for a corn-stack.*

a Fork stuck into the ground. *b* Fork 7½ feet long.
d Man making the circle of stool with his feet.
e c d Circle of stool 15 feet in diameter.

When the outside row is thus laid, an inside row is made with sheaves whose butt-ends rest on the bands of the outside row, thereby securing the outside sheaves in their places, and at the same time filling up the body of the stack firmly with sheaves. A few more sheaves may be required as an inmost row, to raise the heart of the stack at its highest part.

It is of immense benefit to a stack to have its centre hardened with sheaves.

It is the heart sheaves which retain the outside ones in their places in the circle, with an inclination from the centre to the circumference; and it is this incline of the outside sheaves that prevents the

Fig. 483.—*Building a stack of corn.*

e Loaded cart of corn alongside a stack.
f g Sheaves of corn with their butt-ends outwards.
m Carter forking up a sheaf.
k Field-worker receiving the sheaf with a fork.
h Stacker kneeling on the outside row of sheaves.
i Sheaves of the inside row.
l Sheaf placed most conveniently by the field-worker for the stacker.

rain passing along the straw into the heart of the stack, where it would soon spoil the corn.

Size of Stack.—The number of rows of sheaves required to fill the body of a stack depends on the length of the straw and the diameter of the stack. For crops of ordinary length of straw, such as from 4¼ to 5 feet, a stack of 15 feet diameter is well adapted. In such a stack one inside row, along the bands of the outside one, with a few sheaves crossing one another in the centre, form sufficient hearting. Where wheat grows long, from 5 to 6 feet, the stack should be 18 feet in diameter, to give room to a few sheaves for the hearting.

Second Forker.—The stacker should receive the sheaves within easy reach, as he cannot reach far on his knees to take them without loss of time, and risk of making bad work. To facilitate the building, a second forker may be employed to receive the sheaves on a short fork from the carter, and to throw them to the stacker in the position he wants them, to save him the trouble of turning them.

For regularity of work, the carter should pitch the sheaves just as fast as the builder can place them, and no faster, having only one sheaf in reserve on the stack in advance of the builder: any more can be of no service to him, and may be a hindrance.

It is necessary for the second forker to use the fork equally with the right hand and the left, so as to avoid having to swing the sheaves across the body for half the round of the building of the stack.

By another plan which many prefer, the second forker becomes unnecessary. When a stack gets near completion, and the cart at the stack nearly empty, another stack is begun until a cart arrives with a full load, when from the top of it one forker is easily able to send up sheaves for the completion of the former stack.

Trimming Stacks.—As each cart is unloaded, the stacker descends to the ground by means of a ladder, and trims the stack by pushing in with a fork the end of any sheaf that projects farther than the rest, and by pulling out any that may have been placed too far in. As the stack rises above the stacker he cannot trim it with a fork. He uses a *trimmer*, consisting of quarter-inch thick flat board, about 20 inches in length and 10 inches broad, nailed firmly to a long shaft, fig. 484, with which he beats in the projecting ends of sheaves, giving the body of the stack a uniform roundness. An improved trimmer has its edges formed into thick strong teeth.

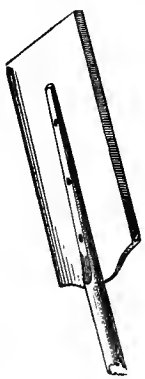


Fig. 484.—*Stack-trimmer.*

Form of Stack.—Many stackers make the stack swell out as it proceeds in height, but this is not necessary for

throwing off the drops of rain from the eave, as the eave itself, on the stack subsiding after being built a few days, or the thatching, projects sufficiently to throw off the drops. The body of the stack should be carried up perpendicularly.

Height of Stack.—As a stack of 15 feet in diameter should ultimately stand 12 feet high in the body to maintain a due proportion, an allowance of about one foot for subsidence, before making the top, is generally given. The height is measured with the ladder, and allowing two feet for the height of the stathel, a 15-feet ladder will just give the desired height of the body before the top is built up. Fig. 491 is a stack built upon a stathel.

Eave.—The eave of a stack is formed according to the mode in which it is to be thatched. If the ropes be placed lozenge-shaped, the eave-row of sheaves is placed just within the topmost row of the body. If the ropes are to run from the crown of the stack to the eave, the eave sheaves project two or three inches beyond the topmost row of sheaves.

Topping Stacks. — In building the top of a stack, every successive row of sheaves is taken as much in as to give the slope the same angle as a common roof—one foot below the square. The bevelled bottom of the sheaves, acquired by standing in the stook, answers the slope of the top pretty nearly. The hearting of the top of a stack should be particularly attended to, as on rain obtaining admission at the top it cannot be prevented descending to the heart. After the area of the top has contracted to a space on which 4 sheaves only can stand upright, they are placed with their butt-ends spread a little out, and the tops pressed together, so as to complete the apex of a cone. The top sheaves are held in their position against the wind by means of a straw-rope wound round them and fastened to the stack.

Process of Thatching.

Seldom is leisure found to thatch stacks as long as there is corn to carry in. The finer the weather the less the leisure. A damp day, however, which prevents carrying, answers well for thatching, as thatch-straw is none the worse of being a little damp; but in heavy rain it is improper to thatch and cover up the wet ends of sheaves. The materials for thatching should all be at hand before commencing —drawn bunches of straw, coils of straw-ropes or coir-yarn, ladders, forks, hand-rakes, and graips. To get on with the business quickly, one man and two assistants are required for each stack — the most thrifty assistants being field-workers, to supply the thatcher with straw and ropes, and tie the ends of the ropes.

Stack-ropes.—For tying down thatch or holding firm the tops of stacks, straw-ropes, once universally used, are now being supplanted by coir-ropes or yarn. This latter material is cheap, durable, and convenient to use. If well cared for, it should last three or more years; and many farmers contend that, especially on large farms, or where straw aud labour are both scarce and dear, the coir-rope is cheaper than the straw-rope.

Straw-rope making.—Nevertheless, straw-ropes are still largely employed, and where they can be made without any appreciable addition to the labour bill, they will likely continue to be used. It will thus be useful to repeat here the information in former editions of this work as to the making of straw-ropes.

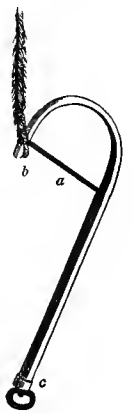


Fig. 485.—*Old throw-crook.*

a Iron stay.
b Protection for end of rope.
c Ferule and swivel ring.
c b Line of direction of rope.

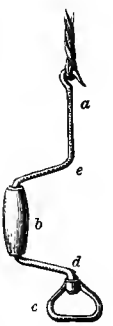


Fig. 486.—*Best throw-crook.*

a Hook, and
a e d Curved spindle of iron.
b Perforated cylindrical handle of wood.
c Swivel-ring.
c b d Curved part of iron spindle.

Straw-ropes are made by means of the

implement named the *throw-crook*. Various forms of this instrument are in use, and one of the simplest is fig. 485.

A better form of throw-crook is fig. 486, where the strain of the straw-rope is in a straight line from the hook, along the spindle to the handle. The left hand holds a swivel-ring, and the right hand causes the curved part to revolve by means of a perforated cylindrical handle of wood, the rest of the instrument being made of iron.

An improved form of spinner consists of a simple contrivance by which one person is enabled to spin two or three ropes at one time. The contrivance hangs from the shoulders of the spinner, who, by turning one handle, gives motion to two or three spindles, to each of which a rope is attached, the spinner moving backwards as the ropes increase in length.

The once common method of twisting straw-ropes by a throw-crook is shown in fig. 487. The left hand of the twister, a field-worker, holds by the swivel-ring, fig. 486.

Straw for Ropes.—The best sort of straw for making into ropes is that of the common or Angus oat, which, being

Fig. 487.—*Making a straw-rope with a throw-crook.*

soft and pliable, makes a firm, smooth, small, tough rope.

The ordinary length of a straw-rope for a large stack is about 30 feet. Counting every interruption, a straw-rope of this length may take five minutes in the making—that is, 120 ropes in ten hours.

Winding Straw-ropes.—After the rope has been let out to the desired length, the man winds it firmly in oblique strands on his left hand and arm into an oval ball, the twister advancing towards him as fast as he coils the rope, which is finished and made firm by passing the end of it below one of the strands.

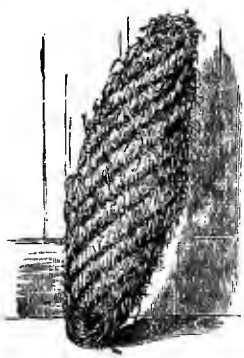


Fig. 488.—*Coil of straw-rope.*

Fig. 488 represents a straw-rope *coiled* up in this form. With the ends smaller than the middle, the rope can be easily taken hold of and carried; and in the oval form instead of the spherical the coil can be more easily thrown upwards to the top of a stack. Still many prefer large circular coils, except for use in forming a network of ropes over a stack, for which small oval bundles are most convenient. Straw-ropes should be spun of such lengths as are suitable to the size of the tops of the stacks.

Thatching.—The material to be used in thatching the stacks must also be in a state of readiness before the crop is brought into the stackyard.

Material for Thatch.—The material most largely used in thatching stacks is straw, which has been previously drawn parallel by the hand and tied into sheaves. The roughest and rankest straw is generally used for thatch. In some cases rushes or other coarse herbage is employed instead of straw.

Drawn Straw.—A common method of drawing straw for thatch is as follows: In commencing to draw straw in the straw-barn, the man takes a wisp from the mow, and, placing it across his body, takes hold of each end of the wisp, and spreading out his arms, separates the wisp into two portions. Holding the ends of both portions in one hand, he takes hold of the other ends with the other hand, and spreading out his arms, draws the straws parallel and straight;

and he does this until he finds the straws parallel and straight, when he lays down the drawn wisp carefully upon the floor of the barn.

The state of the straw, and the kind, render the drawing more or less easy and

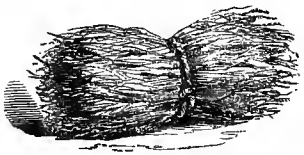


Fig. 489.—*Bunch of drawn straw.*

expeditious. When straw is much broken in thrashing, it requires the more drawing to make it straight; and of all the kinds wheat-straw, being long and strong, is most easily and quickly drawn, barley-straw being shortest and most difficult to draw. Oat-straw is the most pleasant of any to draw.

After as much has been drawn and laid down as to make a bunch of about 15 inches in diameter, the man makes a *thumb-rope* by twisting a little of undrawn straw round the thumb of his right hand, drawing it out with his left and twisting it with his right alternately, until a short coil is made, one end of which he places on the floor by the side of the drawn straw, and puts his foot upon it; and, keeping hold of the other end in his left hand, puts the drawn straw into the rope with his right; and then, holding both ends of the rope, binds the straw into a bunch as firmly, and in the same manner, as a bandster does a sheaf of corn. A bunch of drawn straw is represented in fig. 489.

Thatch-making Machine.—The genius of the inventor has now come to the aid of the farmer in the making of thatch, as in most other of his operations. A thatch-making machine is represented in fig. 490 (Barnard & Lake). The drawn straw is fed into the machine by hand, and the form of the thatch when completed is well shown in the figure. It is found that this machine economises straw, and saves time in thatching.

This machine is also employed in making straw matting to protect pits or clamps of trees, as well as race-courses from frost. It likewise produces excellent material for providing shelter in sheepfolds.

Method of Thatching.—The thatching of a stack with drawn straw is done in this manner: On the thatcher ascending to the top of the stack by means of a ladder, which is immediately taken away by an assistant, one bundle or two of drawn straw are forked up to him by the other assistant, and kept beside him behind a graip stuck into the top of the stack. The straw is first laid and spread upon the eave, beyond which it projects a few inches, and then handful after handful is laid in an overlapping manner to the top. Where a butt-end of a sheaf projects, it should be beaten in; and where a hollow occurs, a sheaf should be drawn out a little, or the hollow should be filled up with additional straw. In this manner the straw is evenly laid all round the top of the stack, to the spot where the thatcher began.

Forming the Apex.—After putting

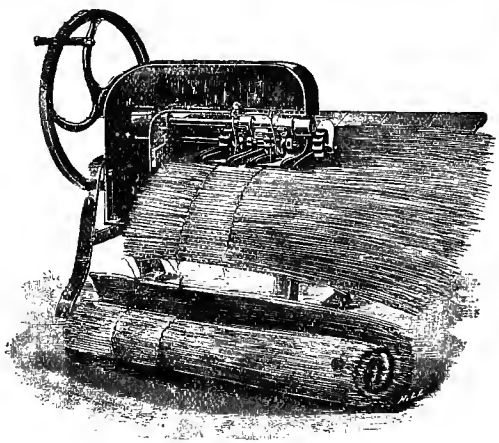


Fig. 490.—*Thatch-making machine.*

the covering on the top of the stack, fig. 491, he makes up the apex with a small bundle of well-drawn long straw, tied firmly near one end with a piece of cord, and the tied end is cut square with a knife; the loose end being spread upon the covering, and giving the finish to the thatching. To secure the apex in its

place, a straw-rope is thrown down by the thatcher, the end of which his assistant on the ground fastens to the side of the stack. After passing the rope round the apex, he throws it down in the same direction, where it is also fastened to the

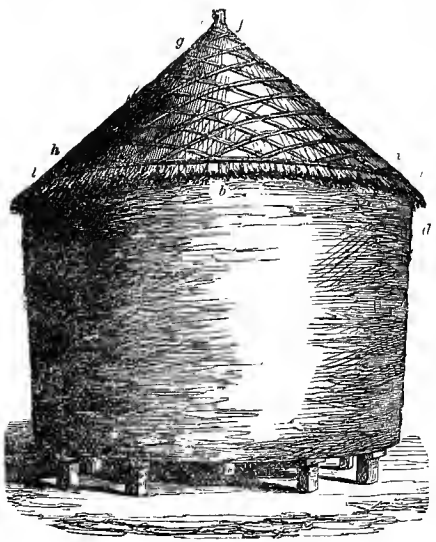


Fig. 491.—*Lozenge mode of roping the covering of a corn-stack.*

a Apex or ornamental top.	*h* Last rope on that side of the stack.
e f First rope for securing the apex in its position.	*i* Last rope on the opposite side of the stack.
f g Second rope for farther securing the apex in its position.	*l* Eave of thatch.
	l k Eave-rope.
	c d Diameter of the stack, 15 feet.

stack. In like manner he throws down a rope round the opposite side of the apex, and their ends are also fastened by the assistant.

Roping Stacks.—Having thus secured the ornamental *top*, the thatcher comes down the thatching, closing up the covering in the descent of his track, and descending by the ladder placed to let him down. Taking a longer ladder, he inclines its upper part nearly parallel to the covering of the stack, and secures its lower end from slipping by a graip thrust against it into the ground. He then stands upon the ladder at a requisite height above the eave, where he receives a number of coils of ropes from his assistant, which he keeps before him between the steps of the ladder.

The thatch-straw is made smooth by being stroked down with a supple rod of willow, before the ropes are successively put on. Holding on by the loosened end of a coil of rope, he throws the coil from where he stands on the ladder down to the right hand to his assistant, who, holding it in the hand, allows the thatcher to coil it up again upon his hand without ruffling the covering of the stack, till as much of it is left as to allow the assistant to fasten it to the side of the stack, while the thatcher adjusts its position parallel to the rope he had placed round the apex. The thatcher then throws the other end of the coil to the right hand to his assistant, who takes hold of its end, while he retains the rope in his hands, and places its double parallel with the rope round the apex, and the assistant pulls it tightly down, and makes it fast to the stack, or perhaps to a brick or other weight.

He then takes the ladder to the opposite side of the stack, and puts on each rope on that side, as he had done on the other side.

Lozenge Roping.—Ropes thus placed parallel from opposite sides of the stack, crossing each other, make the lozenge-shape in fig. 491.

Number of Ropes.—On a stack 15 feet in diameter at the base, 16 feet diameter at the eave, 12 feet high in the body, and 6½ feet high in the top, 10 ropes on each side will secure the thatch.

Tying Ropes.—The ends of the ropes are fastened to the stack by pulling out a little straw from a sheaf, twisting the rope and straw together, and pushing through the twisted end between the rope and the stack.

Windy gusty weather is unfavourable for the thatching of stacks.

Another Method of Roping.—Another method of roping the thatching of a stack is fig. 492. The thatching of straw is put on in the same manner as described above. The ropes cross over the crown of the stack, and subdivide the top into equal triangles, their ends being fastened to the side of the stack. The ropes, at their crossing over the crown, are fastened together by a straw-rope, which is tied above them with cord, and cut off in the form of a rosette. The cross-ropes are either put on spirally round the top till they terminate at the eave, or in separate bands, parallel to the eave. In either

case the cross-ropes are twisted round each crown-rope, at equal intervals, from the top to the eave.

This mode of roping requires more ropes than the last, but it secures the thatch against any force of wind, and is therefore well adapted for exposed situations.

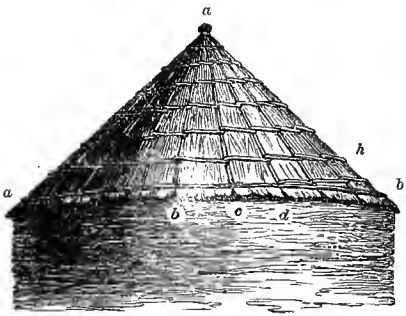


Fig. 492.—*Net-mesh mode of roping the covering of a corn-stack.*

a Top or rosette.
a b, *a c*, *a d* Form of triangles on the thatch.
a to *d* is the spiral rope round the top, from the top to the eave.
g h are ropes round the top parallel to the eave.

Round Tops.—A third mode of roping the covering of a stack is applicable to where the eave is formed of sheaves projecting beyond the body. It is shown in fig. 493, and is common on the Borders. The first thing is to put a strong eave-rope round the stack, below the projecting row of sheaves. The covering straw is then put on in a similar manner to that described, but rather thicker, and it projects farther down than the line of the eave-rope. The tops of the finishing sheaves of the stack are then pressed down, and a hard bundle of short straw is placed upon them, to serve as a cushion for the ropes to rest upon. Upon this the thatcher perches himself, where he receives the ropes as thrown up to him on the prongs of a long fork.

An English Custom.—A mode of thatching stacks, common in England, is the insertion of handfuls of well-drawn wheat-straw into the butts of the sheaves, which are kept down with stobs of willows, or sewed on with tarred twine, being an imitation of thatching cottages. No straw-ropes are used, and, finished by an experienced thatcher, it gives the stacks a neat and permanent appearance. This method would not resist much wind, but its smooth surface would detain the snow a much less time than any of the ropings described above.

Thatching with machine-made thatch is much more expeditious and more simple than any of the methods described above.

Finishing Stacks.—Seldom is the thatching of a stack finished when the straw and ropes are put on,—the object of these being to place, in the shortest time, stacks beyond danger of rain. Besides, stacks subside in bulk after covering. Stacks to be early threshed, as barley, seldom receive finishing; and many farmers only finish the outside row of stacks. It is slovenly management to leave stacks unfinished in the thatching, as wind readily strips them of their thatching.

The finishing of the thatching in fig. 491 is done in this manner: A rope is spun long and strong enough to go round the stack as an eave-rope. Wherever two ropes from opposite directions cross the eave-rope, they are passed round it, and, on being cut short with a knife, are fastened to the stack. After all the ends of the crossed ropes are thus fastened to the stack, the projecting part of the thatch at the eave is cut of equal length with a knife round the stack. Of all the modes of thatching, there is none more efficient or better-looking than the lozenge-shaped.

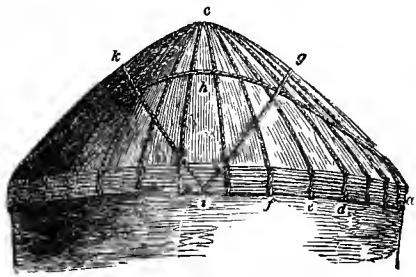


Fig. 493.—*Border mode of roping the covering of a corn-stack.*

c Crown of stack, upon which the thatcher stands.
c b to *c a* Ropes passing over the crown of the stack.
f e d Ends of ropes fastened to the eave-rope.
a b Band of rope-ends round the stack.
h, *i k*, *i g* Strap-ropes quartering the top of the stack.

The finishing of thatching, fig. 492, is as follows: An eave-rope is first put

round the stack. The crown-ropes are passed at each end round the eave-rope, and fastened to the stack. The projecting straw at the eave is cut with a knife at equal length.

The difficult part of roping, fig. 493, is in finishing the eave, which, if well done, looks neat; if not, slovenly. The eave is finished in this way: The eave-rope having been put up at the thatching, the ends of the ropes are loosened from the stack, and passed between the eave-rope and the stack, and each successive end is so passed and carried horizontally along its length; and thus every rope all the way round the stack at both ends is treated; and in carrying the ends of the ropes round the eave, the band of ropes should be of the same breadth round the stack. From four to eight ropes, according to the exposure of the situation, are strapped across the crown-ropes, quartering the top of the stack, and fastened to the eave-rope.

Cutting Thatch.

Where rough grass grows on a farm, as on a bog which is partially dry in summer, it should be mown and sheafed, for thatching stacks. One or two days given to mowing such grass, after the harvest is over, are well spent, even at the rate of wages and food of ordinary harvest-work. Such vegetable materials save the drawing of clean straw when it is scarce, and form good covering for stacks soon to be threshed; and when it has served the purpose of thatch, it is suitable for littering courts. Bog-reeds (*Arundo phragmites*) might be used in the same way where they do not find a profitable market as thatch for cottages. Such materials add many tons to the manure-heap.

Stack-heating.

Barley.—Of all kinds of corn, barley is most liable to heat in the stack, partly owing to the soft and moist character of the straw, and partly because clover is usually mixed with it. On this account it is advisable, in most seasons, to make barley-stacks smaller than the others, both in diameter and height, and to build them upon bosses. Much care should be bestowed on building barley-stacks to heart them properly, which is the best expedient to prevent heating.

Injury from Heating.—The least heat spoils barley for malting, and it should be remembered that malting barley always fetches the highest price in the market. Besides injuring the grain, heating compresses barley-straw very firmly, and soon rots it.

Remedy.—When a stack is seen to heat, it should be instantly carried into the barn and threshed, to cool both grain and straw. If this should be inconvenient, the stack might be "turned"—that is, forked down and rebuilt, the hotter sheaves being kept to the exterior.

Symptoms of Heating. — When a stack begins to lean to one side about twenty-four hours after being built, or shows a depression in the top a little above the eave, you may suspect heating to have proceeded to a serious degree. Incipient symptoms of heating are moisture on the top of a stack early in the morning—indicated by cobwebs—before the sun evaporates it, as also when heated air is felt, or steam is seen to rise.

Heated barley lubricates the threshing-machine with a gummy matter.

Oats.—Oats are less apt to heat than barley, though their heating is stronger. If sap remain in the joints of the straw, oats will be sure to heat in the stack. Heating gives to oat-straw and grain a reddish tinge, may render the straw unfit for fodder, and give the corn a bitter taste.

Wheat. — Wheat seldom heats, but when it does the heat is most violent. Heated wheat is bitter to the taste.

Partial Heating.—Partial heating is induced in a compressed part of a stack caused by bad building, and it is indicated by the stack leaning over.

Propping Stacks.—To prevent a stack from leaning to one side, props of weedings of plantations are loosely set around it to guide subsidence, especially if it has been rapidly built; but in using props caution is required not to push one harder in than others. Stacks often sway whenever their top is finished, when props should be set to keep them upright. To push a prop firmly into a stack much swayed requires the strength of two men —one to push up backwards between the stack and the prop, with both hands clasped upon the outside of the prop, the other to push forward with the shoulder

planted against the prop below the other man's hands.

Stack Ventilators.

Various contrivances have been introduced as safeguards against heating in stacks. These are most generally wooden structures, in Scotland named *bosses*, which signify hollows. The mode of using them is to occupy the space which would have been filled with the heads of the sheaves of corn, with a void into which the air shall find access. When stacks are built on bosses erected on stathels, the air finds access through the stathel; but when built upon the ground, a trestle of woodwork may be connected with the boss, by which the air is led into the interior of the stack. When such a trestle is placed at both sides of a boss, a ventilation is maintained through the body of the stack.

Common Boss.—The most common form of boss is a three-sided pyramid, formed of three small trees, of larch or Scots fir, tied together at the small ends,

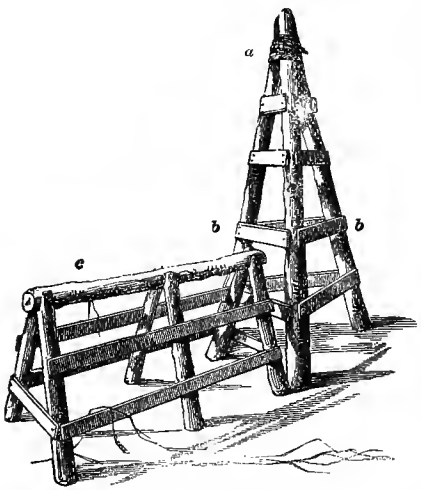


Fig. 494.—*Pyramidal boss and trestle.*
a Tying of 3 sticks together. *b b* Fillets of wood. *c* Trestle.

and the thick ends placed at equal distances upon the stathel or ground. A common boss is shown in fig. 494, where three trees are tied at the top, standing about 8 feet in height and 3 feet asunder. They are fixed together by rows of fillets of wood nailed on, stiffening the pyramid and preventing the sheaves passing into the boss. A trestle, about 2 feet high, is placed on one side to conduct the air into the boss.

An objection to this form of boss is, that as the stack subsides, the sharp apex penetrates through the sheaves and disfigures the upper part of the stack.

Prismatic Boss.—A form of boss which many prefer is shown in fig. 495. It consists of three stems of small trees, 7 feet long, held together in the form of a prism, 3 feet in width, by fillets of wood nailed to them. The prism is set on end, and upon a stathel, which is nailed to it; but as a further means of stability, a spur from each tree might be nailed to the stathel within the prism. Upon the ground it requires a trestle for the conveyance of air.

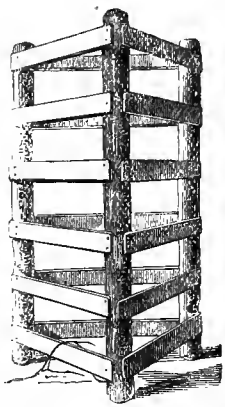


Fig. 495.—*Prismatic boss.*

The advantage of this boss over the other is, that it supports the top of the stack evenly when it subsides, thereby relieving the body of the stack of the weight of its top.

Other Methods.—Other means are employed to form a hollow in the heart of a stack, such as by setting the upright sheaves which form the foundation of the stack around a long cylindrical bundle of straw, firmly wound with straw-rope, or sack filled with hay, and as the stack rises in height, the bundle or sack is drawn up through its centre to the top, where it is removed, leaving a hole through the height of the stack. This hole creates a current of air through the stack, allowing the heated air to escape, while the cool air enters from below by means of a trestle or stathel.

Measuring Heat in Stacks.—The degree of heating in a stack may be found by the stack-thermometer. (Fig. 5, vol. i., p. 26.)

Improved Ventilator.—An excellent

stack ventilator (Taylor's) is represented in fig. 496. It is an effectual ventilator, alike for stacks of grain and hay.

Field Stacks.—It is a common practice with some farmers to build a portion of the crop in the field. This is not commendable in good weather, as, besides the trouble of carrying thatch to the field, much waste is experienced in carrying corn to the steading in winter, when the stacks are wanted, perhaps in bad weather or through deep snow. The stacks there are beyond protection, and subject to depredation. A scheme may be justifiable under peculiar circumstances which would not be in ordinary practice, and the building of stacks in the field is one of them.

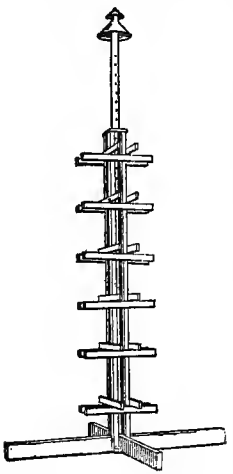


Fig. 496.—*Taylor's stack ventilator.*

ARTIFICIAL DRYING.

Many attempts have been made to introduce some practical method of drying the cereal crops by artificial means. So far, however, little success has been attained.

Hot-air Drying.—The system of drying by a hot-air blast, referred to in the section on Haymaking in this volume, was at one time looked to with considerable hope. Unfortunately, however, it has proved to be impracticable.

Nelson System.—This method, also described in the section on Haymaking, has been tried with fairly good results by some farmers; but it has nowhere come into general or extensive use.

Drying Racks.—The most successful and useful efforts have been those directed to the devising of what are known as "drying racks." These racks consist of contrivances by means of which the sheaves of damp corn may be stored in thin layers in such form as to induce the play of currents of air, and expose the sheaves to the drying influence thus created or encouraged.

In late wet districts it has long been the custom, in cases of slow drying, to build imperfectly dried corn on hurdles or other wooden erections in what is called the "sow" form. The sheaves are built, perhaps only one sheaf deep, on both sides, and on the top of a long wooden frame. The hollow centre is left open at both ends, and a current of air is thus kept playing upon the thin layers of sheaves. The sheaves are built with the head towards the hollow centre of the rack, so that the grain is not only protected from wet, but directly exposed to the internal current of air.

By resorting to some such plan as this, corn which would otherwise be seriously damaged is often tolerably well preserved.

THE RICHMOMD GRAIN-DRYING RACK.

An ingenious and efficient rack, invented and brought into use by Mr John Richmond, Dron, Bridge of Earn, Perthshire, is worthy of special notice.

Its construction is described by Mr George W. Constable in the *Transactions of the Highland and Agricultural Society of Scotland* for 1897. The appearance of the rack when empty is shown in fig. 497, and when filled with corn in fig. 498. As to the details of construction, Mr Constable writes:—

The two sides are 5 feet apart, and can be formed of any length, from 100 to 130 yards long being considered amply sufficient for a moderately sized farm.

The usual height is 16 feet, and the whole erection is covered with a roof of corrugated iron. There are four large straining-posts, one at each corner, while intermediate standards (*X X*, fig. 499) are erected 4 yards apart, on which the wires, after being secured to the straining-posts, are supported. The straining-posts, which should not be less than 10 inches in diameter at the small end and 22 feet long, must be sunk into the ground at least 6 feet. A beam of wood 9 feet long and 6 inches in diameter at

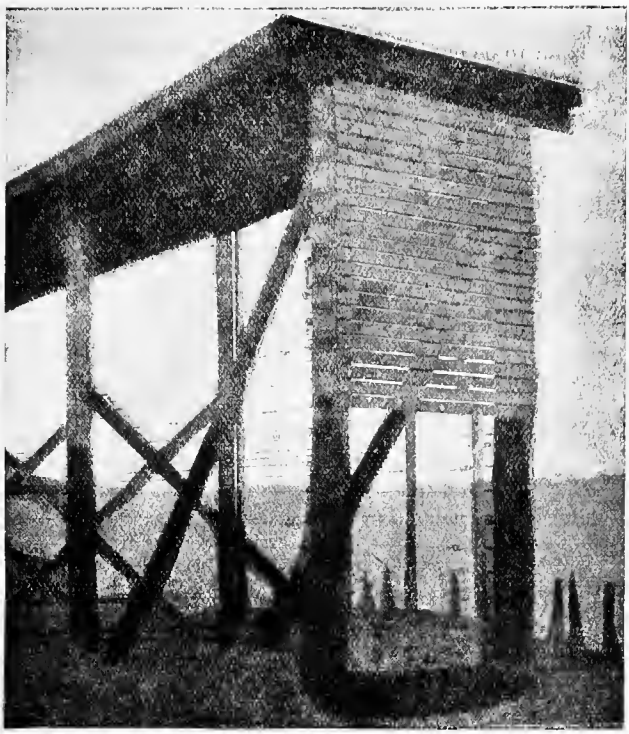


Fig. 497.—*Richmond drying-rack – Empty.*

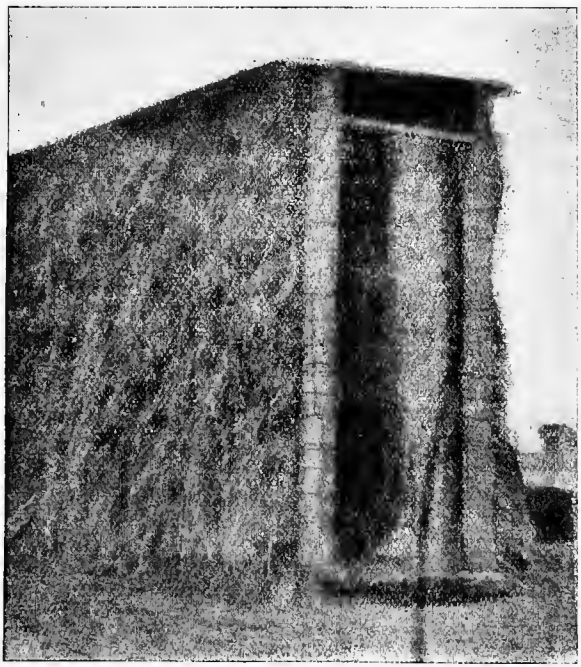


Fig. 498.—*Richmond drying-rack—Full of grain.*

the small end ought to be put across the foot of both posts to act as a heel, and the strainers should be embedded in concrete from the foot of the post to about

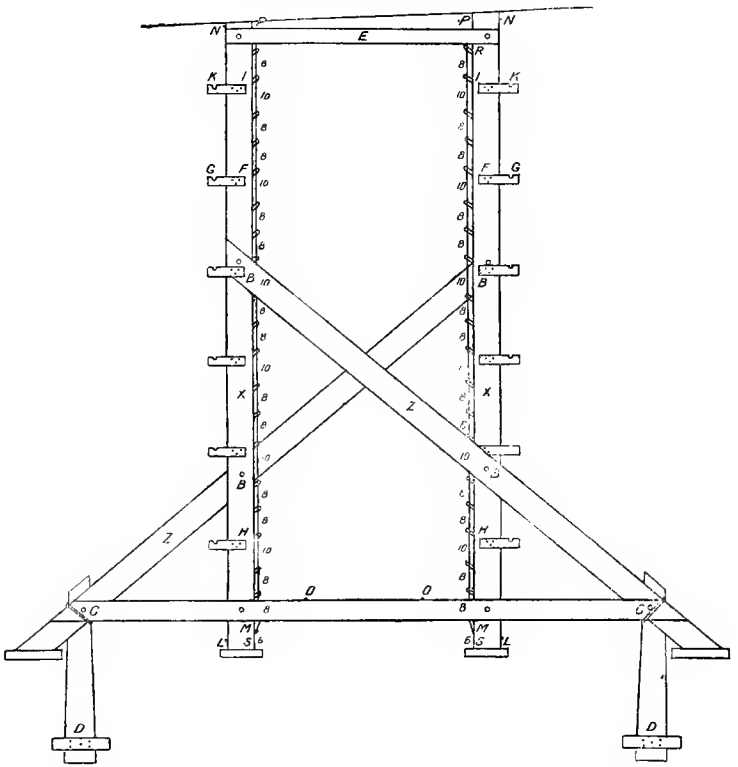


Fig. 499.—*Richmond drying-rack—section.*

2 inches above the level of the ground (fig. 500), and thus secure the post from yielding a hair's-breadth. Strong stays are also required, firmly founded and

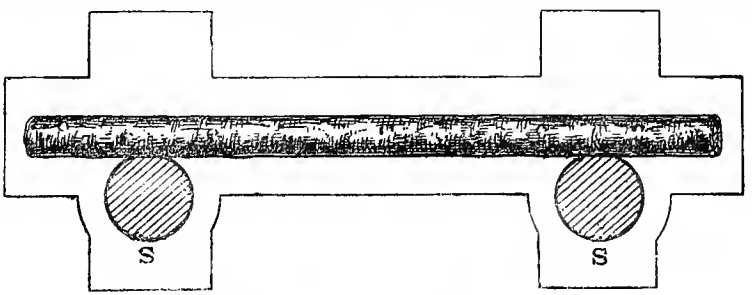


Fig. 500.—*Cross-beam fixing strainers.*

secured, to assist the strain of so many wires.

The uprights (*X X*, fig. 499) and the struts or rances (*Z Z*, fig. 499) should rest on square fireclay bricks or flat stones, raised so as to have the top about 2 inches above the ground.

Staples are used to support the wires

on the intermediate standards. The staples should be driven in the standards at a steep angle, and so driven that the wire will rest on both legs of the staple, and just sufficient left undriven as will support the wires, besides allowing room for a wire to pass down *through* the staples, so as to keep the wires resting on the staples confined between the wood of the standard and this upright wire passing down through the staples. About 1 inch undriven will serve the purpose. Staples 2½ inches long, made of No. 4 galvanised wire, will suit. The distances between the staples on the *inside* of standards should be 8 inches, 8 inches, and 10 inches respectively from top to bottom, or according to the size of sheaves made—the first staple beginning 6 inches from the foot of the inside of the standard (*N*, fig. 499). Each standard should be ranced both ways, and the rances should pass through the 10-inch or wide spaces on both uprights (*B*, fig. 499).

Bolts should be used for fixing the rances and crossbars to the intermediate standards.

A strong larch post should be pitted, not driven, at least 3½ feet into the ground at the foot of each rance, and bolted or strongly nailed thereto, also strongly secured by twisting and stapling wire several times round post and rance (*C*, fig. 499). The thick end of the post should be sunk in the ground, and a crossbar 1 foot long should be notched and nailed to foot of post (*D*, fig. 499). The foot crossbars of standards (*E*, fig. 499) should be about 2½ inches wide by 1½ inch thick. The top crossbar (*F*, fig. 499) should be 3½ inches by 2 inches and 9½ feet long.

The uprights of intermediate standards should be made of battens 16 feet long, 6½ inches by 2½ inches, and the rances should be 6 inches by 2 inches.

A batten 2 inches by 3 inches should be fixed by bolts to top and bottom crossbars, and also to the rances (*G*, fig. 499). This batten should be 2½ inches distant from the standard; a staple should be driven into the batten opposite *each wire-space of* 10 *inches* and 2 inches below the level of the staple at the top of the 10-inch space on the standard (*H*, fig. 499).

The staples in the batten should be driven in the same way as those in the standard, so as to support the outside wires, and a wire should be passed down through the staples, as in the standards. The outside wires will thus be 1 foot distant from the inside wires.

Wires. — No. 6 wire (galvanised annealed) should be used, and a hand ratchet should be employed for stretching each wire. The wires are stretched between the end straining-posts and rest on the staples on the inside of the standards, also on the staples on the outside of the batten (see *K* for inside wires and *L* for outside wires, fig. 499).

An additional wire should be firmly stapled on the *outside* of the standards 1 inch below the level of the lowest *inside* wire, to keep the posts from moving off the bricks or stones (*M*, fig. 499).

The lowest *inside* wire should also be firmly stapled for the same purpose (*N*, fig. 499).

A wire ought also to be stretched between the straining-posts and affixed to the top of each intermediate standard (*O*, fig. 499), so as to keep the standards in an upright position. A couple of wires, or more, should be stretched from beams fixed to the outside of the straining-posts, the said beams being on a level with the foot crossbars of the standards, the wires resting on those foot crossbars (*P*, fig. 499). Nails can be used to keep these wires in their proper place, enough being left undriven for that purpose. These wires form a floor to keep the heads of the lowest sheaves off the ground.

Roof.—The most suitable roof is corrugated iron. If the inside wires are 5 feet apart, the roof should be 10 feet wide. An incline of half an inch to the foot will be sufficient.

The four runners (*R*, fig. 499) supporting the roof should be 5-inch battens, in lengths sufficient to cover two spaces between intermediate standards, and should be notched 2 inches into the top of intermediate standards and top crossbars (*R R*, fig. 499).

The runners, besides being nailed to the top of the standards and crossbars, should be strongly stapled down with wire. The corrugated iron should be bolted or screwed with washers to the runners.

The runners must not be nailed to the ends of the strainers, but should be kept in their places by being passed loosely through an iron socket, so as to allow for the slight yielding of the strainer brought about by the wire pressure. If this is not done the roof may bulge. Top crossbars should be attached to the strainers, the same as those on the intermediate standards,

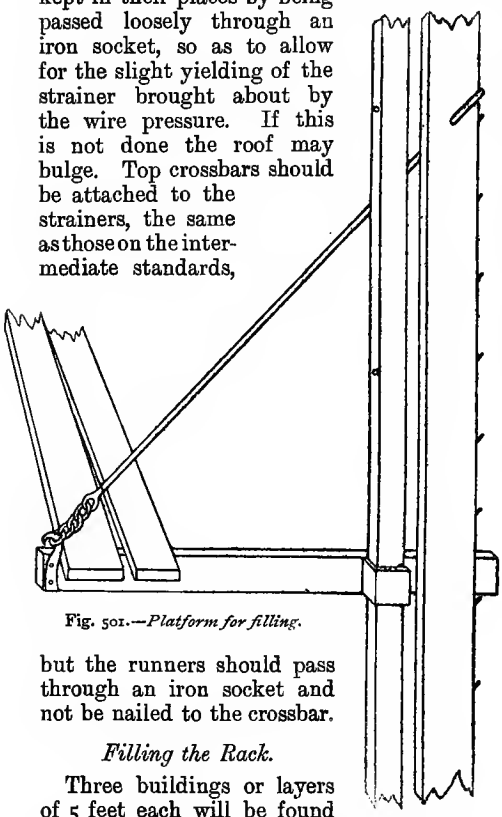


Fig. 501.—*Platform for filling.*

but the runners should pass through an iron socket and not be nailed to the crossbar.

Filling the Rack.

Three buildings or layers of 5 feet each will be found most convenient. One building from the ground and two from platforms are thus required.

The platforms are formed of two planks supported on two brackets, a sketch of which is seen in fig. 501. The hanging rod (fig. 502) of the bracket is hooked on to the standard above any wire at the height necessary, and a few links of a chain at the other end of the rod affix it to the bracket. The bracket (fig. 503) is made of hard wood, 4 inches by 2 inches, with a strong iron clasp.

In filling, raise the second lowest wire off its supporting staple and hang it by an "S" hook to the wire immediately above, so as to allow room for the first wire to be filled with sheaves. The sheaves should slope downwards by being overbalanced *outwards*, the stubble end of the first row of sheaves resting on straw, branches, or stones laid on the ground, the heads of grain being kept off the ground by the wires (*P P*, fig. 499), on the foot-ties or crossbars.

When the lowest wire is filled, let down the wire above to its original place, and lift the next one above to the wire above it; then lay the sheaves across the one wire, the stubble end of the sheaf resting on the stubble end of the sheaf below. The next row should be done in the same way.

When the outside wires are reached, a handful of the stubble end of every third sheaf (or if the crop is a short one, every second or each sheaf) should be passed underneath the outside wire, and the sheaf drawn outwards till the wire nearly touches the band of the sheaf. The double wires at these regular 10-inch spaces give a downward slope to the sheaf,

Fig. 502.—*Hanging-rod for platform.*

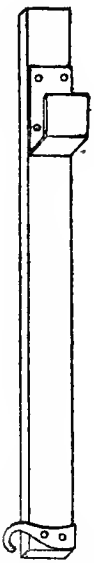


Fig. 503.—*Bracket for platform.*

as in a well-built stack; they also prevent the body of sheaves from slipping outwards, acting like a through-

band in a wall, and they further admit ventilation between this row of sheaves and the set below. Air-holes may be left at intervals if required, according to the condition of the grain.

Newly cut grain can be packed more closely than grain which has been soaked with rain after being cut.

When filled, a space exists within the rack from end to end between the heads of the sheaves, allowing air to play on the loose heads of the sheaves, and thus obviating the smallest chance of heating.

To prevent a half side-wind from blowing sheaves outwards, both ends of the rack should be sparred to about half-way down: the spars should be about 1 inch apart. Put wire-netting on the lower half in order to keep out birds.

The end of the rack should if possible face the prevailing winds, and it should not be put in a sheltered situation. The most convenient site for it is alongside a farm-road.

The ground does not require by any means to be level. The only precaution necessary is to see that there is not a hollow between the extremities of the rack, as such would have a tendency to loosen the wires when tension is applied.

Contents.

A rack 100 yards long, 16 feet high, with wires distant from each other 8 inches, 8 inches, and 10 inches respectively from top to bottom, will provide room for about 20,000 sheaves.

About 800 sheaves, 8 inches in diameter, may be taken as an average crop per imperial acre; and thus a rack of the above dimensions will hold the produce of fully 25 acres.

It must, however, be clearly understood that it is quite possible to fill and empty the rack at least twice in one harvest. Thus if a crop, say, of barley, be put in dry immediately after cutting, should the weather be at all favourable, in a short time—a few days at most—it will be ready to thresh, and the rack can be again filled. Of course, if the crop be put in *very* wet, it necessarily will require a longer time to get into condition, but it cannot heat or go wrong.

Advantages of the Rack.

The advantages claimed for the Richmond rack are not confined to the saving of the grain and straw in a bad harvest. When the rack is used the crop can be carted straight from the reaper or binder without being stooked, and each day's cutting might be secured by night. Then the rack saves thatch, ropes, kilns, bosses, and props, and the setting up and moving stooks in bad weather. No skilled hands are required for building; any ordinary farm hand can build. It dispenses with keeping on extra hands at a high wage in a late protracted harvest, and the owner of a rack can have all his hands employed filling the rack when other harvest work is at a standstill. It enables the farmer to clear the ground of grain much sooner, so that stubble-ploughing or other work may be proceeded with. The grain gets into condition for threshing much sooner than in a stack; and invariably the weight per bushel is increased and the quality of the grain is superior.

In a good season all crop round woods, hedgerows, and in sheltered positions can, with the aid of the rack, be at once secured after cutting; and thus what on most farms is the worst conditioned grain—no matter how good the season may be—is by the rack made equal to the best.

Cost.

The cost of erecting a rack of 100 yards long amounts to about £58, with a patent fee of from £2, 2s. to £5, 5s. for each farm.

Convertible into a Shed.

If the season be exceptionally fine, the rack, by removing the wires (a simple process), can be converted into a shed for filling with grain, when in this way it will hold four times as much as with the wires. Thus a rack 100 yards long, turned into a shed, will hold 100 acres of average crop, and no thatch, ropes, bosses, or props are required.

GRAIN-DRYING SHED.

An improvement upon a grain-drying rack alone is a combination of a rack and a shed. A structure of this kind, erected by Mr M. G. Thorburn of Glenormiston, in the county of Peebles,

is described in the *Journal of the Board of Agriculture and Fisheries* for December 1907, full information being given for the building of the shed and rack. By the kind permission of the Board of Agriculture and Fisheries a representation of this combined shed and rack is given here in fig. 504.

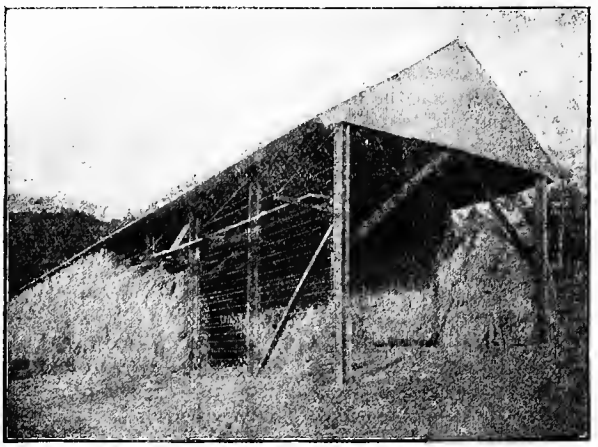


Fig. 504.—*Combined grain-drying rack and shed.*

OTHER RACKS.

Several other forms of drying racks are in use over the country, most of them quite simple in construction. A simple and serviceable rack was invented in Perthshire in the wet harvest of 1907 by two neighbours, the Rev. Mr John M'Ainsh and Mr C. Robertson. Grain racks need not be elaborate or costly, and any handy man can erect one for himself without the aid of a trained joiner.

HARVESTING BEANS, PEAS, AND TARES.

The leguminous crops, having stiff or trailing stems, are more difficult to reap than the cereals.

Beans.

If sown tolerably early, beans will likely in an average season be ready for reaping towards the end of September. They should not be so ripe as that the pods will open and allow the beans to escape. Examine the crop carefully as it approaches maturity, and cut it whenever the eye of the bean is black and the skin has acquired a yellowish colour and leather-like appearance.

The reaping is generally done by the common sickle, and the produce of four drills is laid in handfuls in one row.

In some cases the beans are left lying in this form for a few days, and then turned, and shortly afterwards lifted and bound into sheaves with short straw-ropes, previously provided, and the sheaves are then stooked. In other cases they are bound and stooked as reaped.

In many instances the reaping-machine is now employed in cutting beans.

When peas are sown with beans, the haulm of the peas makes excellent bands. In some cases beans are bound by their own straw.

A bean-stook, which consists of 4 or more sheaves, is never hooded. Bean-sheaves should always be kept on end,

as they then resist most rain. If allowed to remain on their side after being blown over by the wind, little rain soaks them, and a succeeding drought causes the pods to burst and spill the beans upon the ground.

Sometimes to admit of preparations for a succeeding wheat crop, the beans as soon as cut are removed from the field and stooked elsewhere.

Peas.

Whenever the straw and pods of peas become brown they are fit for reaping. In seasons when the straw grows luxuriantly, it is cut down whilst retaining much of its greenness. On account of their trailing stems, peas are difficult to cut, and the best work is perhaps made by the hook. The reaping-machine and scythe are, however, both used for the purpose.

Peas as a rule are not bound at first, but laid in loose bundles on the ground, where, after drying for some time, according to the state of the weather, the bundles are rolled into an oblong form and made firm by a wisp of their own straw. The bundles may be set together in pairs to form a sort of stook, or left singly over the surface of the field. Many consider that it is a better plan not to tie the bundles at all, but to turn them over once a-day until sufficiently dry, and then carry direct to the stack in the loose form. A man or boy, with a pitchfork, will turn the pea-bundles at the rate of an acre an hour. The turning over of the bundles should be done in the cool of the morning, and with as little shaking as possible, not to open the pods.

Tares or Vetches.

Tares are most easily and quickly reaped by the reaping-machine or scythe. To win they are placed in bundles and treated in the same way as the pea crop. Tares are sometimes seen spread over strong hedges as they are cut, and there they dry quickly.

In dry and warm seasons, peas and tares may be harvested as early as the cereal grains; but beans are always long in winning, and sometimes are not harvested until three weeks after the other crops.

STACKING PEAS AND BEANS.

Peas.—Pea-straw is very apt to compress in the stack, and to heat, and should therefore be built with bosses, either in round stacks or oblong ones like a haystack. When peas become very dry in the field, the pods are apt to open and spill the corn in sunny weather — to avoid which, they should be carried and built on bosses.

Beans.—Beans are a long time of winning in the field in calm weather. If the land they grow on is desired for wheat, they should be carried to a lea-field and stooked till ready to be stacked. Being hard and open in the straw, they keep well in small stacks, though not quite dry; and there is risk of keeping them in the field in dry weather after much rain, when the pods are apt to burst and spill the corn. In building both pea and bean stacks, the sheaves are laid with their corn-end inwards, and tramped with the feet. The stacks receive but little trimming, the peas none at all, the beans with the back of a shovel.

Thatching Peas and Beans.—The thatching of pea and bean stacks is done in the manner described for grain, but less pains are bestowed in finishing it. As, however, a good deal of corn is exposed on the outside of pea and bean stacks, their bodies are also thatched with straw, kept on with straw-ropes.

REAPING BUCKWHEAT.

The buckwheat is a plant remarkably affected by the weather. It requires dry weather on being sown, and it springs in the greatest drought. But after putting forth its third leaf, it must have rain for the development of its flowers. During the long time it continues in flower, alternate rain and sunshine are requisite to set the flower. The flower drops off in thunderstorms, and it withers in cold east winds. After flowering, dry weather brings the seed to maturity.

Buckwheat ripens very unequally, for the plant is continually flowering and setting, and therefore the crop is cut at the time the greatest quantity of grain is ripe.

In the south of England a period of

hot and dry weather is necessary in autumn to harvest buckwheat.

Cutting.—Buckwheat may be reaped with the sickle, scythe, or machine, or it may be pulled up by the roots, which last method is recommended by some as less likely to shed the seed when fully ripe. In dry weather it should be reaped early in the morning, or late in the evening, when the dew is upon it, and should not be moved too much in the day.

Drying.—Buckwheat may be tied up in sheaves, or made into bundles like peas; but, in either way, it should be protected from birds, which are very fond of the seed. Owing to the thick knotty stems of the straw, the green state in which it is cut, and the late period it comes to harvest, a succession of fourteen or fifteen fine days is requisite to dry it sufficiently for stacking. It should be turned and moved several times in preparing it for the stack, and these acts should be done gently and in the dew, the least to disturb the seed; but the plant does not easily spoil when lying on the ground. To be early carried, it should be built in small stacks with bosses.

CORN AT THE STEADING.

In the first volume of this edition (pp. 175-184) some information is given on the providing of suitable means for the stacking and threshing of corn, the storing of straw, and the dressing and storing of grain. Here these matters will be dealt with in fuller detail.

THRESHING-MACHINES.

An Ancient Threshing-machine.—The following quaint "Advertisement anent the threshing-machine" appeared in the *Caledonian Mercury* of August 26, 1735: "Whereas many have wrote from the country to their friends in town about the price of the threshing-machines, the following prices are here inserted, for which the machines will be furnished (with the privilege of using them during the patent) by Andrew Good, wright in Edinburgh, whose house and shop are in the College Wynd—viz., to those who have water-mills already, one which will thresh as much as 4 men, costs £30 sterling. . . . One which threshes as much as 6 men, £45; 8 men, £60; and so on, reckoning £7, 10s. for each man's labour that the machine does, which is but about the expense of a servant for one year, whereas the patent is for 14 years. One man is sufficient to put in the corn to any one of 'em and take away the straw. . . . About 6 per cent of the grain which is lost by the ordinary method of threshing may be saved by this machine. . . . One of the machines may be seen in said wright's yard in the College Wynd."

The old-fashioned forms of built-in threshing-machines, at one time so extensively used throughout this country, and some of which were illustrated and described in former editions of *The Book of the Farm*, are now rarely met with. Machines of a much more efficient character have taken their place. The portable threshing-machine is now largely used, and is growing in favour. Still many farmers, especially in Scotland, prefer to have a good modern threshing-machine, built permanently in their steadings, to be always at their hand for use when desired.

These built-in machines now, as a rule, accomplish their work in a most admirable manner, threshing the grain at a rate formerly undreamt of, and in many cases not only at the same time dressing the grain so as to be fit for market, but conveying it into the granaries, which may be some considerable distance from the threshing-machine, and also carrying the straw to the remotest end of a long straw-barn — all this being done automatically, no human hand touching either grain or straw, after being fed into the drum, until each is deposited in its appointed quarters. These modern

built-in threshing-machines are of many patterns, several of which may be said to be equally efficient.

Scottish Threshing-machine. — A section of the threshing-mill wing of a modern Scottish steading is represented in fig. 505. This shows at a glance not only the position of the threshing-machine, but also the courses of the grain and the straw until the former is dressed and carried by elevators and oscillating spout into the granary, and the latter by shakers and a travelling web to the extreme end of the straw-barn.

The following is a working description of this machine, as erected by the late Mr R. G. Morton, Errol, Perthshire :—

The sheaves to be threshed are fed through the hopper A, the grain being driven from the husk by the drum B in its grated concave *cc'*, which is regulated for the different kinds and conditions of grain, by an instant and parallel acting set-gear D*d'*. A large portion of grain and chaff fall through *c*, while the remainder is discharged, at a tangent, amongst the straw by the centrifugal force of the drum against the reflecting board D', then dropping upon the shakers E. The straw is tossed forward to the straw-carriers by the action of cranks on shaft F, and the patent balance throw-

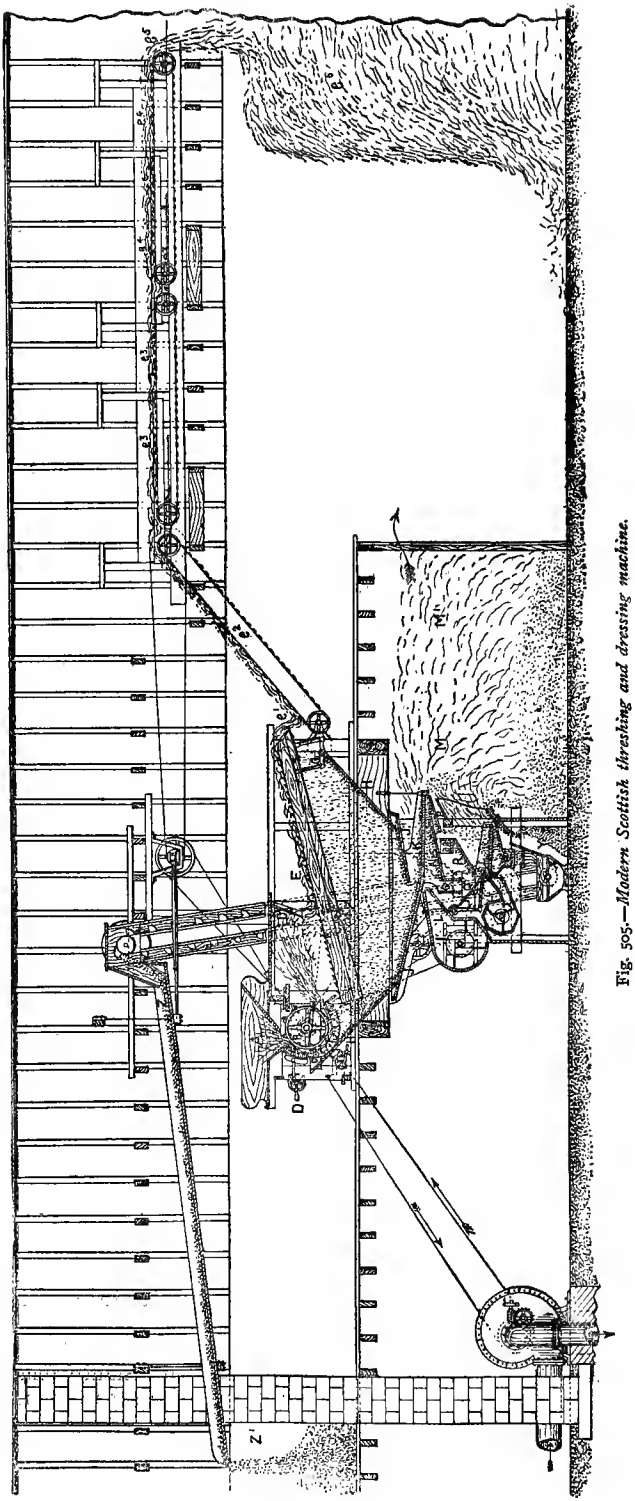


Fig. 505.—*Modern Scottish threshing and dressing machine.*

gear G. The grain falling through the shaker and concave gratings is gathered by the inclined planes H*h*, and oscillating planes JJ′ of first riddle K, which, by the current of air from first blast L, carries the chaff, short straws, &c., to chaff-room MM′, while the good grain falls through K to plane N, from which it slides down to cross-spout *o*. The light grain, &c., blown over N, falls on plain P, over which it slides and falls into the current of air from second blast T, to be further cleaned as it falls into the light-grain compartment Y; while the good grain falls through a trap-door in spout *o*, from whence it slides down the inclined planes Q and R to oscillating plane S, and receives the current of air from second blast T, as it falls from *s* to second riddle *v*, the wind carrying all the lights over *v* into *y*. The remaining husks and dust are blown into chaff-room M. The good grain falls through *v* into oscillating spout *w*, which, with a perforated bottom for extracting the small seeds and sand, delivers the good grain to elevator ark X, to be carried up to the roof and discharged into vibrating inclined plane Z, passing over a series of sand, seed, and small grain extractors, and being delivered through the gable into the granary Z′ for storage or bagging.

When the grain requires awning the trap-door in cross-spout *o* is closed, the grain passing over same to the patent pneumatic awner (shown by dotted lines at back of machine) and discharged into vertical tube, the air carrying the dust, &c., up same, while the grain falls down to the bottom of the tube and enters the machine by the port *aa*, and slides down the plane R to the oscillating plane S, to be winnowed and riddled as above.

The threshed straw as it leaves the shakers E at *e* 1 falls on the first section of straw-carriers *e* 2, to be delivered above the balks on to second section *e* 3, which in like manner delivers on *e* 4, which drops it into straw-barn at *e* 5, to be stored as at *e* 6 until full, when pinion 7 is caused to turn in rack 8. The frame and pulley 9 are drawn along with it, making an opening at 10, where the straw drops to the barn-floor, the operation being repeated at 11.

The whole parts of this machine are driven off drum-coupling, which is driven by "Morton's" direct-acting poncelet turbine, set in corn-room, designed for 34 feet fall and 26 feet suction, with 130 cubic feet of water per minute, making 509 revolutions, and developing 11½ horse-power. The power required is 9 horse-power and 100 cubic feet water per minute.

The best of these modern machines often thresh and dress from 12 to 16 quarters of ordinary oats per hour. Much, of course, depends on the length of the straw and the wealth of grain in the crop. From 6 to 8 quarters per hour are common quantities.

By ingeniously constructed blasts worked in conjunction with the threshing-machine, the newly threshed and dressed grain is in some cases conveyed, or rather blown, into granaries situated at awkward angles from the threshing-machine, where one would scarcely consider it possible to have such work accomplished.

By extension or contraction of the travelling-web the straw may be carried to the extreme end of the longest straw-barn, or, as already indicated, dropped at intermediate points as desired.

Saving of Labour. — A remarkable saving of labour is effected by these mechanical contrivances, and this, of course, is a point of great importance. The dressing-machines attached to the most improved threshing-mills are so effective as to dress the grain sufficiently well for ordinary purposes; and thus, when the grain is to be immediately sent to market, it may also be bagged —and not only bagged but also weighed automatically, as it issues from the spout at Z′. To accomplish this automatic bagging and weighing, means are provided for hanging a bag upon or underneath the mouth of the spout, so as to catch the grain. The bag rests upon a portable weighing-apparatus, upon which are placed weights equal to the weight which it is desired to have in each bag. As soon as the bag receives the proper quantity of grain, it of course presses down its side of the weighing-machine, and in the act of thus descending it disengages a sluice, which thereupon shuts up the mouth of the spout. The attendant instantly removes the full bag, hangs on an empty one, and lifts the sluice,

and the operation goes on with admirable speed and precision.

It is only in exceptional cases that the automatic work is carried on to this extent, but the practicability as well as the advantages of the plan are obvious enough.

Portable Threshing-machines.—The portable form of threshing-machines prevails in England. As a rule, there is no threshing-machine of any kind in English farm-steadings. The threshing is done by travelling machines owned by companies or individuals, who may have several machines at work in different parts of the country at one time. This system is now also pursued to a large extent in Scotland. Fig. 506 shows Clayton & Shuttleworth's portable threshing-machine at work in a stackyard.

Several leading firms of implement-makers have given much attention to the manufacture of portable threshing-machines, and now the farmer has ample choice of machines of the highest efficiency. These portable threshing-machines are usually worked by steam traction-engines, which also draw them from one place to another. In some

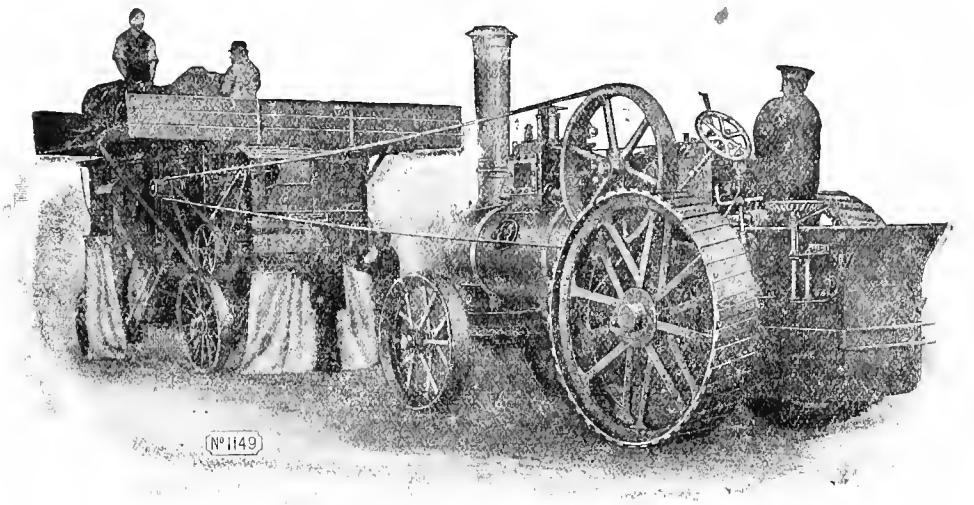


Fig. 506.—*Portable threshing-machine at work.*

cases portable steam-engines are employed in working the machines, but then horses have to be used in taking the machine from farm to farm.

In fig. 507—a longitudinal section of a modern portable threshing-machine, made by Marshall & Sons, Gainsborough—the operations of threshing, dressing, and bagging, all going on simultaneously, are shown clearly. The working is seen so distinctly in the sketch, that no detailed description of the process is necessary. The machine is supposed to be working in the stackyard. The sacks of grain as they get filled have to be conveyed to the granary—but that is easily done.

The disposal of the straw entails more labour. It is usually formed into a large stack at the rear of the threshing-machine, and the conveyance of the straw from the shakers to this stack is, in most cases, accomplished by means of elevators, which can be lengthened and raised in the pitch as the stack increases in height. Fig. 508 represents the Hayes patent elevator (Clayton & Shuttleworth).

Hands required for Threshing-machines.—The number of persons required to work these portable threshing-machines varies according to the operations performed and the speed of the machine. Ransomes, Sims, & Jefferies, whose portable threshing-machine is represented in fig. 509, point out that the economy of threshing must depend in a great measure on the proper distribution

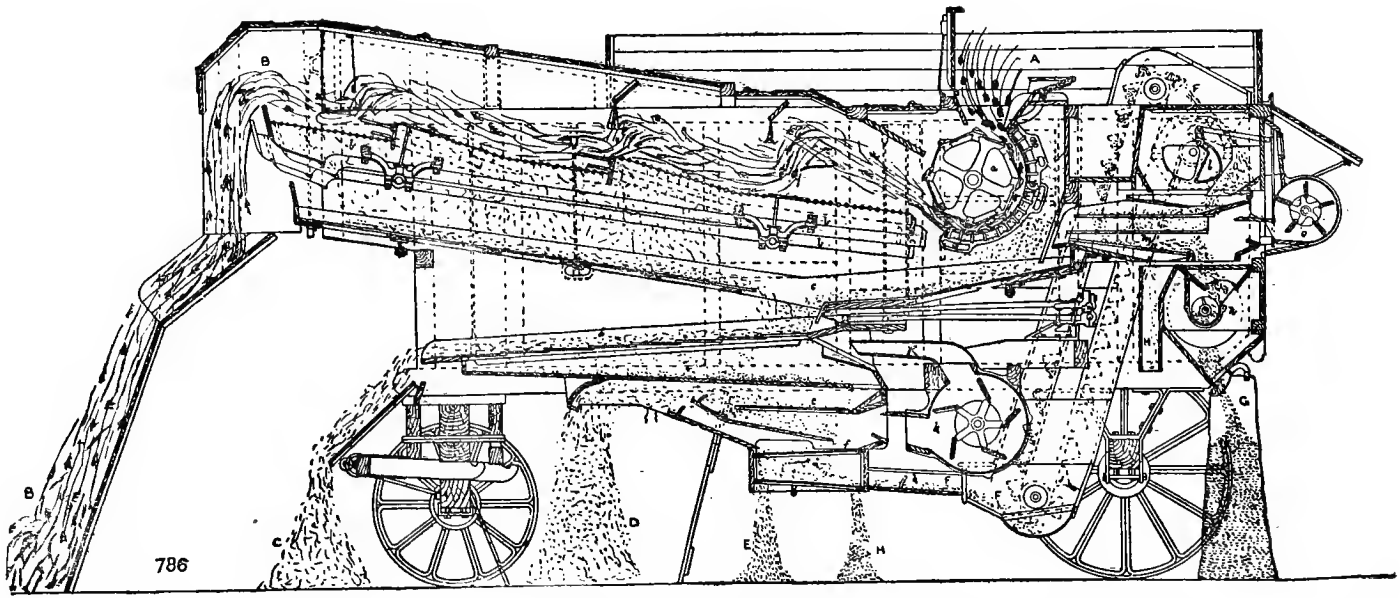


Fig. 507.—*Section of portable threshing-machine.*

A Unthrashed corn.
B Straw.
C Cavings.
D Chaff.

E Cobs.
F Corn.
G Finished grain.
H Dust.

a Drum.
b Shakers.
c Top shoe.
d Caving riddle.

e Chaff riddle.
f Caping riddle.
g Screen.
h Corn spout.

j Elevator tins.
k Main blower.
l Smutter.

m Finishing riddles.
n Separating screen.
o Back-end blower.

of the hands employed, and state that the force, when straw-elevators are not used, should consist of eleven men and boys, to be engaged as follows: "One to feed the machine; two to untie and hand the sheaves to the feeder; two on the corn-stack to pitch the sheaves on to the stage of the threshing-machine;

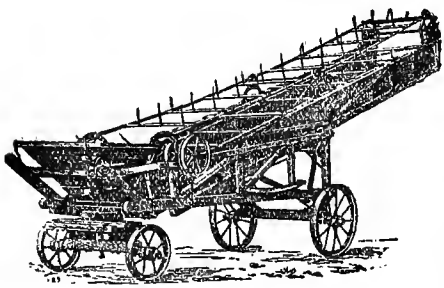


Fig. 508.—*Straw and hay elevator.*

one to clear the straw away as it falls from the straw-shaker; two to stack the straw; one to clear away the chaff from underneath the machine, and occasionally to carry the chobs which fall from the chob-spout up to the stage, to be threshed again; one to remove the sacks at the back of the machine as they are filled; and one to drive the engine. The feeder, on whom very much depends, should be an active man, and should have the control of the men stationed near the machine. He should endeavour to feed the drum as nearly as possible in a continuous stream, keeping the corn uniformly spread over the whole width. The two men or boys who untie the sheaves should stand on the stage of the threshing-machine, so that either is in a position to hand the feeder a sheaf with ease, but without obstructing the other. The men on the stack must keep the boys or men on the stage constantly and plentifully supplied with sheaves, which must be pitched on to the stage, so that the boys can reach them without leaving their position. The man who removes the straw from the end of the shaker should never allow it to accumulate so that it cannot fall freely. The man whose duty it is to clear away the chaff and cavings from underneath the machine must not allow these to accumulate so as to obstruct the free motion of the shoes; he must watch the basket under the chob-spout, and as soon as it is full, empty its contents on to the stage, in a convenient position for the feeder to sweep the same, a little at a time, into the drum to be threshed over again. The man who attends to the sacks must remove them before they get so full as to obstruct the free passage of the corn from the spouts, otherwise the clean corn may be thrown out at the screenings-spout.

When a large quantity is being threshed at one time, additional hands may be required to take away and stack the straw. It is better to cart the sheaves to the threshing-machine than to shift its position in the stackyard. The engine-driver, during threshing, should be as prompt as possible in attending to the signals for stopping and starting, and he should carefully attend to the bearings of the drum-spindle and other spindles of the threshing-machine.

Safety-drums.—The frequency of serious accidents to those engaged in feeding threshing-machines led to the passing of an Act of Parliament providing that the drum and feeding-mouth of every threshing-machine must be sufficiently and securely fenced so far as practicable. Great ingenuity has been displayed by

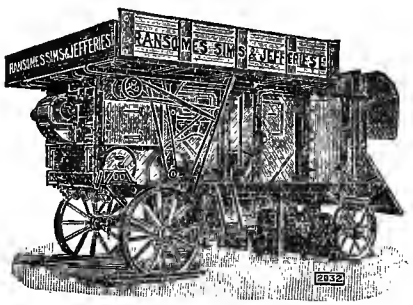


Fig. 509.—*Portable threshing-machine.*

leading manufacturers in devising means for preventing these accidents, and now there are several patent safety-drums or drum-guards, most of which seem to render accidents by contact with the drum, if not absolutely impossible, at least extremely improbable.

Straw-trusser.—The straw-trusser is a most useful contrivance. It is attached to, and worked in conjunction with, a

threshing-machine. The straw as it leaves the shakers of the threshing-machine is caught by the trusser, securely tied in convenient bundles—which may at will be varied in size—with stout

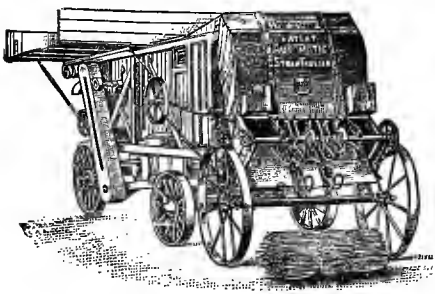


Fig. 510.—*Straw-trusser.*

twine, and thrown on the ground behind the machine, ready to be forked on to a stack or cart. This excellent machine, represented in fig. 510, made by J. & F. Howard, Bedford, will tie up the straw as fast as it leaves the most speedy threshing-machine, thus performing the work of five or six men. As indicated in the illustration, the threshing-machine and trusser attached takes up very little more space than the threshing-machine by itself.

Hand Threshing-machines.—Several tiny threshing-machines are made for hand-power, and there are machines somewhat larger, but still, of course, of a comparatively small size, for one-horse or pony-gear. Some of these threshing-machines, adapted for hand, pony, or horse power, are capable of threshing from 10 to 25 bushels of grain per hour. They are extensively used on small holdings, where they are supplanting the "flail," which is now almost a thing of the past.

A very useful little threshing-machine, arranged for driving by hand and foot, or by other power (Ben Reid & Co.), is illustrated in fig. 511.

MOTIVE POWER FOR THRESHING-MACHINES.

Steam- or oil-engines are fast taking the place of horse-power in working threshing-machines. Where the supply is plentiful, water still holds its own, and will continue to do so, for it is the cheapest of all motors for the purpose. But the horse-wheel is gradually disappearing, and, for threshing purposes, the windmill may be said to have gone.

Steam-power.

The steam-engine in its various forms, suitable for farm-work, has already been fully explained (vol. i. pp. 404-428), so that nothing more may be said in regard to it here. Steam-power possesses two important advantages: it is always at command and can be completely controlled. By the use of steam the threshing may proceed continuously as long as may be desired; while, except in the rare cases in which the force of running

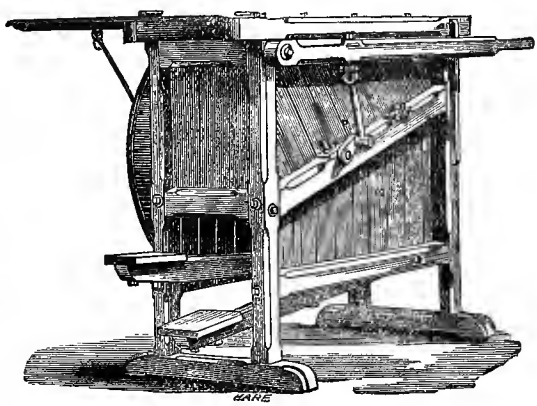


Fig. 511.—*Small threshing-machine.*

water is sufficient to drive the mill-wheel, the threshing for the time ceases with emptying of the "mill-dam." Experience has abundantly proved that threshing-machines dependent on water derived chiefly from the drainage of the surface of the ground, frequently suffer from a short supply in autumn, and late in spring or early in summer, thereby creating inconvenience for the want of straw in the end of autumn, and the want of seed or horse-corn in the end of

spring. Wherever such casualties are likely to happen, it is better to adopt a steam-engine or oil-engine at once.

The other advantage is also important. Water- or horse-power cannot be so nicely governed as steam or oil, and, as a consequence with these powers, irregularities in feeding-in the grain or variations in the length of the straw are apt to make the motion of the corn-dressing appliances irregular, which, of course, causes imperfect dressing.

Water-power.

But wherever there is a sufficient fall and a reliable supply of water, it is desirable, for the sake of economy, that the latter should be utilised for threshing purposes. There are various methods by which water-power is made available for driving the threshing-machine, pulper, chaff-cutter, grist-mill, &c. The turbine is a comparatively modern invention, and a valuable contrivance it is. The water-wheels are usually of two kinds—*undershot* and *bucket* wheels.

Undershot Water-wheels. — The *undershot* or *open float-board* wheel can be advantageously employed only where the supply of water is considerable and the fall low. It therefore rarely answers for farm purposes, and need not be discussed.

Bucket Water-wheel.—A much more useful kind is the *bucket*-wheel, which may be *overshot* or *breast*, according to the height of the fall. It is this wheel that is adopted in all cases where water is scarce or valuable, and the fall amounts to 6 or 7 feet or more, though it is sometimes employed with even less fall than 6 feet.

Measuring the Water-supply.—When it is proposed to employ a stream of water for the purpose of power, the first step is to determine the *quantity delivered by the stream in a given time.* This, if the stream is not large, is easily accomplished by an actual measurement of the discharge, and is done by damming up the stream to a small height, say 1 or 2 feet, giving time to collect, so as to send the full discharge through a shoot, from which it is received into a vessel of any known capacity, the precise time that is required to fill it being carefully noted. This will give a correct measure of the water that could be delivered constantly for any purpose. If the water be in too small a quantity to be serviceable at all times, the result may be found by a calculation of the time required to fill a dam of such dimensions as might serve to drive a threshing-machine for any required number of hours.

If the discharge of the stream is more than could be received into any moderately-sized vessel, a near approximation may be made to the amount of discharge by the following method: Select a part of its course, where the bottom and sides are tolerably even, for a distance of 50 or 100 feet; ascertain the velocity with which it runs through this space, or any measured portion of it, by floating light substances on its surface in a calm day, noting the time required for the substance to pass over the length of the space. A section of the stream is then to be taken, to determine the number of superficial feet or inches of sectional area that is flowing along the channel, and this, multiplied into five-sixths of the velocity of the stream, will give a tolerable approximation to the true quantity of discharge—five-sixths of the surface velocity, at the middle of the stream, being very nearly the mean velocity of the entire section.

Supposing the substance floated upon the surface of the stream passed over a distance of 100 feet in 20 seconds, and that the stream is 3 feet broad, with an average depth of 4 inches—here the area of the section is exactly 1 foot, and the velocity being 100 feet in 20 seconds, gives 300 feet per minute, less one-sixth = 250 feet, and this multiplied by the sectional area in feet, or 1 foot, is 250 cubic feet per minute for the discharge.

It is to be borne in mind that this is only an approximation, but it is simple, and from repeated experiments we have found it to come near the truth.

The next step is to ascertain the fall, by levelling, from the most convenient point at which the stream can be taken off, to the site where the water-wheel can be set down, and to that point in the continuation of the stream where the water can be discharged from the wheel, or what is called the outfall of the tail-race. If the water has to be conveyed to any considerable distance from the point where it is

diverted from the stream to the wheel, a lade must be formed for it, which should have a fall of not less than 1½ inch in 100 feet, and this is to be deducted from the entire fall. Suppose, after this deduction, the clear fall be 12 feet, and that the water is to be received on a bucket-wheel whose power shall be equal to 4 horses.

Horse-power in a Stream.—It may be useful to know the rule for calculating the number of horse-power any stream may exert if employed as a motive power. It is this: multiply the specific gravity of a cubic foot of water, 62½ lb., by the number of cubic feet flowing in the stream per minute, as ascertained by the preceding process, and this product by the number of feet in the fall, and divide by 33,000 (the number of pounds raised 1 ft. high in 1 min. by a "horse-power"); the product is the answer.

Thus, — Multiply the number of cubic feet flowing per minute in the stream—suppose . . .	350
By the weight of a cubic foot of water 62½ lb.	62½
	175
	700
	2100
	21,875
And then multiply the product by the number of feet of fall available—suppose . . .	12
Divide the remainder by	33,000)262,500(7.9 horse-power.
And the quotient, 7.9, gives the number of horse-power.	

This is, of course, the theoretical horse-power, of which only a proportion can really be utilised, varying from 35 per cent in undershot wheels to 75 per cent in turbines.

Mill-dam.—If the stream does not produce this quantity, a dam must be formed by embanking or otherwise, to contain such quantity as will supply the wheel for three or six hours, or such period as may be thought necessary.

Forming Mill-dam.—The *dam* may be formed either upon the course of the stream, by a stone weir thrown across it, and proper sluices formed at one side to lead off the water when required; or, what is much better, the stream may be diverted by a low weir into an intermediate dam, which may be formed by digging and embankments of earth, furnished with sluice and waste-weir, and from this the lade to the wheel should be formed. The small weir on the stream, while serving to divert the water, when required, through a sluice to the dam, would, in time of floods, pass the water over the weir, the regulating sluice being shut to prevent the flooding of the dam. This last method of forming the dam is generally the most economical and convenient, besides avoiding the risk which attends a heavy weir upon a stream that may be subject to floods. When water is collected from drains or springs, it is received into a dam formed in any convenient situation, which must also be furnished with a waste-weir, besides the ordinary sluice, to pass off flood-waters.

The position of the sluice in the dam should be so fixed as to prevent the *wrack* floating on the surface of the water finding its way into the sluice, and thence to the water-wheel. To avoid this inconvenience, the sluice should not be placed at the lowest point of the dam, where it most commonly is, but at one side, at which the water will pass into the lade, while the rubbish will float past to the lowest point.

Dimensions of the Bucket-wheel.—The water-wheel should be on the *bucket* principle, and, for a fall such as we have supposed, 12 feet, should not be less than 14 feet diameter; the water, therefore, would be received on the breast of the wheel. Its circumference, with a diameter of 14 feet, will be $3.1416 \times 14 = 44$ feet; its velocity, at 5 feet per second, is $44 \times 5 = 220$ feet a minute; and 234 cubic feet per minute of water spread over this gives a sectional area for the water laid upon the wheel of $\frac{234}{220} = 1.06$ feet; but as the bucket should not be more than half filled, this area is to be doubled $= 2.12$ feet; and as the breadth of the wheel may be restricted to 3 feet, then $\frac{2.12}{3} = .704$ foot, the depth of the shrouding, equal to 8½ inches nearly; and if the wheel is to have wooden soling, 1 inch should be added to this depth already found, making 9½ inches.

The Arc.—The *arc* in which the wheel is to be placed must have a width sufficient to receive the wheel with the toothed segments attached to the side of the shrouding. For a bucket-wheel it is

not necessary that it be built in the arc of a circle, but simply a square chamber —one side of it being formed by the wall of the barn, the opposite side by a wall of solid masonry, at least 2½ feet thick: one end also is built up solid, while the opposite end, towards the tail-race, is either left entirely open, or, if the water is to be carried away by a tunnel, the water-way is arched over and the space above levelled in with earth. It is requisite that the walls of the wheel-arc should be built of square-dressed stone, having a breadth of bed not less than 12 inches, laid flush in mortar, and pointed with Roman cement.

Construction of the Wheel.—Fig. 512 is a *sectional elevation* of the wheel. The barn-wall, and the sole of the arc

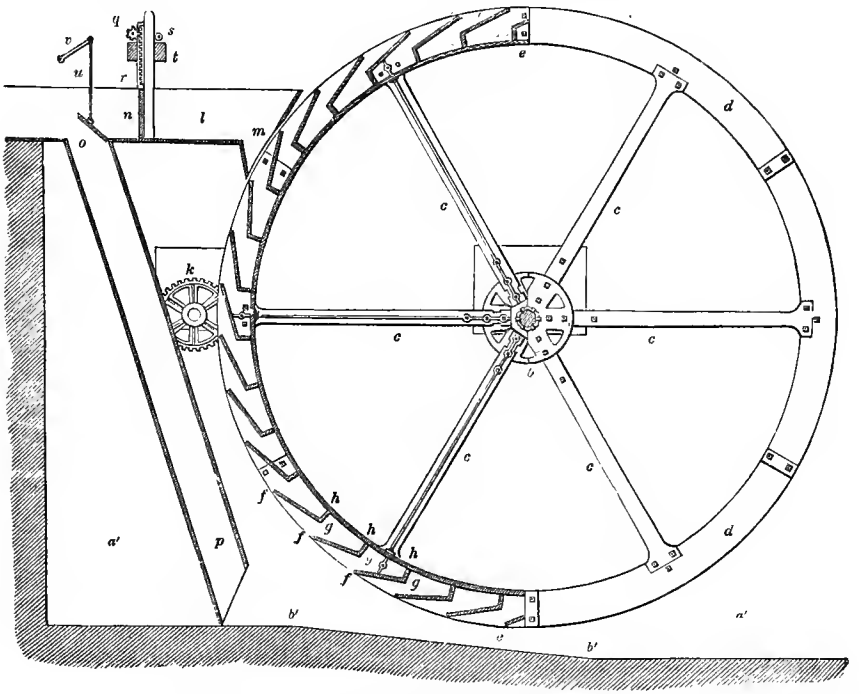


Fig. 512.—*Section and elevation of a bucket water-wheel.*

a' a' Barn-wall.	*f g* Front of bucket.	*r* Sluice-stem.
b' b' Sole of arc.	*g h* Bottom of bucket.	*s* Friction-roller.
b Eye-flanges.	*k* Pinion.	*t* Cross-head.
c Arms.	*l* Trough.	*o* Trap-sluice.
d d Shrouding.	*m* Spout.	*o p* Spout.
e Groove for securing the buckets.	*n* Regulating-sluice.	*u* Connecting rod.
f f Pitch of the buckets.	*q* Pinion.	*v* Crank-lever.

or chamber, are formed of solid ashler, having an increased slope immediately under the wheel, to clear it speedily of water. The shaft, the arms, and shrouding are of cast-iron, the buckets and sole being of wood; and to prevent risk of fracture, the arms are cast separately from the shrouding. The width of the wheel being 3 feet, the toothed segments 4 inches broad, and they being 1 inch clear of the shrouding, gives a breadth over all of 3 feet 5 inches, and when in the arc there should be at least 1 inch of clear space on each side, free of the wall. The length of the shaft depends upon how the motion is to be taken from the water-wheel. In the case of the wheel illustrated in the sketch it is taken off by the pinion shown on the left hand, in a line horizontal to the axis of the water-wheel.

The eye-flanges, 2 feet diameter, are

separate castings, to which the arms are bolted; the flanges being first keyed firmly upon the shaft. The shrouding is cast in segments, and bolted to the arms and to each other at their joinings. On the inside of the shroud-plates are formed the grooves for securing the ends of the buckets and of the sole-boarding.

The form of the buckets should be such as to afford the greatest possible space for water at the greatest possible distance from the centre of the wheel, with sufficient space for the entrance of the water and displacement of the air. In discharging the water from the wheel also, the buckets should retain the water to the lowest possible point. These conditions are attained by making the pitch of the buckets, or their distance from lip to lip, 1½ times the depth of the shrouding; the depth of the front of the bucket inside, equal to the pitch; and the breadth of the bottom as great as can be attained consistently with free access of the water to the bucket immediately preceding: this breadth, inside, should not exceed two-fifths of the depth of the shrouding.

If there is the least danger of back-water — that is, of interruption to the discharge in the tail-race—it is a good plan to keep the bottom of the arc high at the up-water side. This gives the water discharging at the higher points a velocity greater than 5 feet per second, and assists in driving the water away from below the lowest discharging buckets.

In the illustration one-half of the shrouding-plates are removed, the better to exhibit the position of the buckets. The *shrouding-plates* are bolted upon the buckets and soling by bolts passing from side to side; and in order to prevent resilience in the wheel, the arms are supported with diagonal braces. The toothed segments which operate on the pinion are bolted to the side of the shrouding through palms cast upon them for that purpose, and the true position of these segments requires that their pitch-lines should coincide with the circle of gyration of the wheel: when so placed, the resistance to the wheel's action is made to bear upon its parts, without any undue tendency to cross strains. For that reason it is improper to place the pitch-line beyond the circle of gyration, which is frequently done, even upon the periphery of the water-wheel. The determination of the true place of the circle of gyration is too abstruse to be introduced here, nor is it necessary to be so minute in the small wheels, to which our attention is chiefly directed: suffice it to say, that the pitch-line of the segment wheel should fall between one-half and two-fifths of the breadth of the shrouding, from the extreme edge of the wheel.

Overshot or Breast?—An important point to decide is whether the wheel is to be worked on the overshot or breast method. Where the fall is ample but the supply of water small, or moderate, the overshot is the best; where the water is fairly plentiful and the fall not so great, the breast may be most suitable. But whether the water be delivered over the top of the wheel or on the breast, the water should be allowed to fall through such a space as will give it a velocity equal to that of the periphery of the wheel when in full work. Thus, if the wheel move at the rate of 5 feet per second, the water must fall upon it through a space of not less than .4 foot; for, by the laws of falling bodies, the velocities acquired are as the times and whole spaces fallen through to the squares of the time. Thus the velocity acquired in 1″ being 32 feet, a velocity of 5 feet will be acquired by falling .156″; for $32 : 1'' :: 5 : .156''$, and $1''^2 : 16 :: .156''^2 : .4$ foot, the fall to produce a velocity of 5 feet. But this being the minimum, the fall from the trough to the wheel may be made double this result, or about 10 inches.

So as to secure the proper filling of the buckets, the breast-wheel at 5 feet per second should have the pen-trough, with two or three guide-vanes set to turn the direction of the water into the bucket at a velocity of about 6 feet per second. This will also prevent the force of the water from opposing the wheel. For an overshot wheel at 6 feet per second at the periphery, it would be well to have the water entering the bucket at about 7 feet per second.

Trough and Sluices. — The trough which delivers the water upon the wheel

should be at least 6 inches less in breadth than the wheel, to give space for the air escaping from the buckets, and to prevent the water dashing over at the sides: the trough and spout convey the water to the wheel. It is convenient to have a regulating sluice, that serves to give more or less water to the wheel; and this is worked by a small shaft passing to the inside of the upper barn. The shaft carries a pinion working the rack of the sluice-stem, a small friction-roller being placed in proper bearings on the cross-head of the sluice-frame; and this apparatus is worked inside the barn by means of a lever handle upon the shaft of the pinion. As a waste-sluice, the most convenient and simple, in a mill of this kind, is the trap-sluice, which is simply a board hinged in the sole of the trough, which in opening turns up towards the wheel. It is made to shut close down to the level of the sole, and when so shut the water passes freely over it to the wheel. The lifting of this sluice is effected by means of the connecting-rod and crank-lever, the latter being fixed upon another small shaft, which passes through the wall to the interior of the barn, where it is worked in the same manner as the lade-sluice. When it is found necessary to stop the wheel, the trap is lifted, and the whole supply of water falls through the shoot, leading it to the bottom of the wheel-arc, by which it runs off, until the sluice at the dam can be shut, which stops further supply.

Speed of the Wheel. — The wheel here described, if it moves at the rate of 5 feet per second, will make 6¾ revolutions per minute. The pinion-shaft will carry a spur-wheel, by which all the other parts of the machine can be put in motion. The rate of the spur-wheel depends on the relation of the water-wheel and its pinion. In the present case they are in the proportion of 8 to 1, and as the water-wheel takes 6¾ revolutions per minute, this, multiplied by 8, will give 54 to the spur-wheel.

The Turbine.—The turbine is much superior to the ordinary vertical wheels for utilising water-power, and it is rapidly taking their place. It is an ingenious and powerful water-engine, one of the many useful inventions we owe to the development of science. It is suitable for high or low falls, and, as a rule, can be fitted in at much less cost than the common vertical water-wheel. The power which the turbine generates can be applied very easily, and the "engine" can be worked at different degrees of its capacity, so that it may be adapted either to the working of the chaff-cutter, root-pulper, or grist-mill alone, or to the threshing-machine and all the smaller machines combined. The turbine makes the most both of the water and the fall. As its action is not impeded by back-water, the turbine may be placed on a level with the tail-race, and thus give the water before entering the turbine the full benefit of the entire available fall. Its small size is another advantage, and a small bed of masonry is all that is required for its foundation. Turbines revolve with such velocity that the motion for driving machinery may be obtained direct from the wheel-shaft, thus saving intermediate gearing.

Turbines of various types are in use in this country and elsewhere.

Horse-power.

As already indicated, horse-power for threshing purposes is gradually giving place to other motors. Still it is in use on many farms, and it demands brief notice.

Formerly there were two leading types of horse-wheels, known as *under-foot* and *over-head*. The under-foot was used chiefly where small powers are required, and the over-head on large farms where four horses and upwards were employed. But on nearly all large farms either the steam-engine, oil-engine, or turbine water-wheel has taken the place of horse-power for threshing, so that the over-head horse-wheel is now rarely seen in use. It is therefore the under-foot horse-wheel that now prevails, and with it the horses draw by means of trace-chains and swing-tree. The horses usually worked singly, one at each lever or beam; but sometimes they are yoked in pairs, two horses at each lever. It is often found that horses accustomed to go together in the plough work most willingly in the horse-wheel when yoked side by side; and in this way also a greater force may, if desired at any time, be em-

ployed than with one horse to each lever or beam.

Horse-gear for one or two horses is now provided in great variety, and, as a rule, of a very convenient and serviceable description, easily fitted up or removed from one place to another. Only threshing-machines of small proportions can be worked by this form of horse-gear. Its most general function on the farm is to drive the chaff-cutter, turnip-cutter, cake-breaker, and grist-mill.

THRESHING AND WINNOWING CORN.

In bygone days the first preparation for threshing corn—that is, separating the grain from the straw by the threshing-machine—was usually taking in the stack to be threshed, and placing it in the upper or threshing barn. Now the almost universal plan is to cart the unthreshed corn from the stack to the threshing-mill or machine. The corn is usually carted to the sheaf-barn as the threshing proceeds; but in many places where there is sufficient sheaf-barn accommodation, a stack is stored there at some convenient time and threshed out at another time, or at intervals, according to circumstances.

In many cases where the threshing-machine is fed from the ground-floor, or where a cart-way can be made up to the level of the sheaf-barn on the first floor, the sheaf-door is made wide enough to admit the load of straw, which is deposited there by a tip-cart without any further handling. Where the sheaf-door is not wide enough to admit the load, the sheaves are usually forked off the cart into the barn. Where the floor of the sheaf-barn is level with the ground outside, the load of sheaves may be tipped at the door and carried or forked in. This is an expeditious plan when only one cart is employed in taking in the stack; but it has this drawback, that the tipping is apt to shake out grain from the straw.

Ladders.—Ladders are most useful about a farm-steading. They are best formed of tapering Norway pine spars, sawn up the middle. A useful form of ladder for farm purposes is in fig. 513, where the rounded form of the Norway spar, divided in two, is placed outmost, though it is as often placed inmost. Those spars are connected together by steps of clean ash, pushed through auger-made holes in the spars, and rendered firm by means of wedges driven into the outside ends of the steps. The steps are 9 inches apart, and 16 inches long at the bottom and 13 inches at the top, in a ladder of 15 feet in length, which

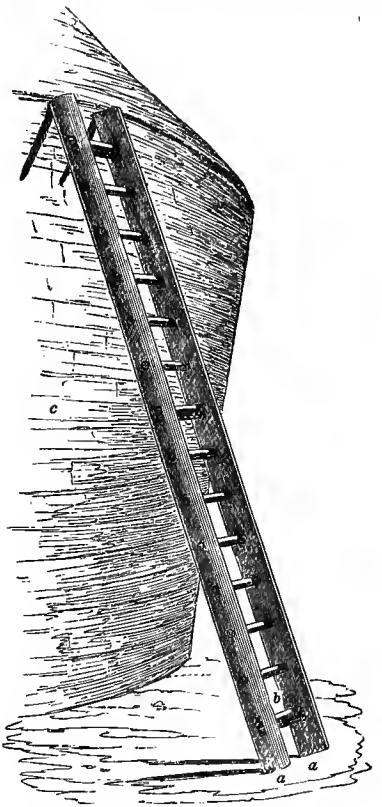


Fig. 513.—*Ladder, 15 feet long.*
a a Spars of ladder. *c* Stack.
b Steps of ladder.

is the most useful size for use in a stack-yard. To prevent the ladder from falling to pieces in consequence of the shrinking of the round steps, a small rod of iron is passed through both spars, having a head at one end and a screw and nut at the other, *under* the upper, middle, and lower steps, the head end keeping its hold firmly while the screw end is rendered tight by the nut. When well finished and painted, such a ladder will last many years. A

couple of ladders 10 feet, a couple of 15 feet, and one of 24 feet long, will suffice for all the purposes of a farm, as also for the repairs of the steading and houses.

Preparing for Threshing.—Before setting on the threshing-machine, its several parts require to be *oiled*. Fine machinery-oil should be employed for this purpose, though too often a coarse dirty oil is used. It should be put for use into a small tin flask, having a long narrow spout (fig. 514) to reach any gudgeon behind a wheel. It is important that the machine should be thoroughly oiled, and it should therefore

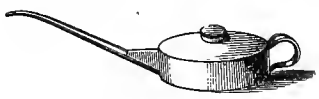


Fig. 514.—*Oil-can.*

be carried out with great care, and by one acquainted with the construction of the machine.

When steam is employed as the motive power, the fire should be kindled by the engine-man in time to get up the steam by the moment it is wanted. From half an hour to an hour may be required for this purpose, according to the state of the atmosphere. Less time will suffice to start an oil-engine.

When water is the power, the sluice of the supply-dam should be drawn up to the proper height, to allow the water time to reach the mill-wheel sluice when it is wanted.

When the power is of horses, the horses are yoked in the wheel by their respective drivers, immediately after leaving the stable at the appointed hour of yoking; and while one of the men is left in charge of driving the horses, the other men go to the straw-barn to take away the straw from the shakers of the mill with straw-forks, and fork it in mows across the breadth of the barn, which mows may be tramped down by a woman in narrow breadths—that is, where the straw is not carried away automatically, which is done with most modern threshing-machines, as in fig. 505.

Every preparation ought to be completed before the machine is started by the order of the person who is to feed the machine, and who should be a careful man of experience. The power should be applied gently at first, and no sheaf should be presented until the machine has acquired its proper momentum—the *threshing motion*, as it is termed.

Care in Feeding.—The capacity of the modern threshing-machines compels the feeder to be active at his work. The efficiency of the threshing, however, is not now so much dependent upon the care and skill of the feeder as was the case with the old-fashioned machines formerly in use. With the improved high-speed drums, the best modern machines make a perfect separation of the grain and the straw even with unskilled feeding, yet it is desirable that this important piece of work should be executed carefully.

Irregular Driving.—There are certain circumstances which greatly affect the action of the machine in the *foulness* of its threshing. One depends—where horse-power is used—on the *driving of the horses*, in which a considerable difference is felt by the feeder when one man keeps the horses at a regular pace, whilst another drives them by fits and starts. The regular motion is most easily attained by the driver walking round the course in *the contrary direction to the horses*, in which he meets every horse twice in the course of a revolution, and which keeps the horses upon their mettle, every horse expecting to be spoken to when he meets the driver.

Removing Straw.—The straw, as it is threshed, is either carried away to the straw-barn automatically, as shown in fig. 505, or trussed as in fig. 510, or is removed by forkers, who place it in the part of the straw-barn where it is intended to be stored. One method of storing straw in the barn is to spread it in a line, across the end or along one side of the straw-barn, in breadths or mows of 5 or 6 feet, and tramp it firmly with the feet; and when this breadth has reached such a height as the roofing of the barn will easily allow, another one is made upon the floor beside it, and so on in succession, one breadth after another, in parallel order, until the stack is threshed or the barn filled. When stored in this form the straw can be more easily taken away in forkfuls as required.

Dressing Corn.

In former times the threshing and dressing of grain were distinct operations performed at different times. Now they may be said to be but two parts of one operation. The modern threshing-machine of the most improved type is so admirably equipped as to efficiently clean and dress the grain, as well as separate it from the straw; also "hummelling" or "beating" the barley, and, as has already been explained, conveying the grain to the granary, and the straw to the extreme end of the straw-barn—all this in one continuous operation.

Still there are many farms on which the threshing-machines only partially dress the grain, and not a few indeed, mostly of small size, where the threshing-machines do little or nothing except separate the grain and the straw. It is therefore necessary to have at least one detached corn dressing-machine at every farm to give the grain such finishing touches as may be required.

Modern Winnowers. — The modern corn-dressers, worked in conjunction with the threshing-machine, are, as a rule, built upon similar principles to those on which the old-fashioned detached winnowers so long in use in this country were constructed, but many improvements have been introduced which enhance their efficiency. The blowing, finishing, and dusting—that is, the blowing away of the chaff, the separating of the light grain from the heavy, and the removal of sand and dust—are now all performed by one machine,—a machine of which there are numerous patterns, made by various firms, many of them very ingenious, and nearly all very efficient.

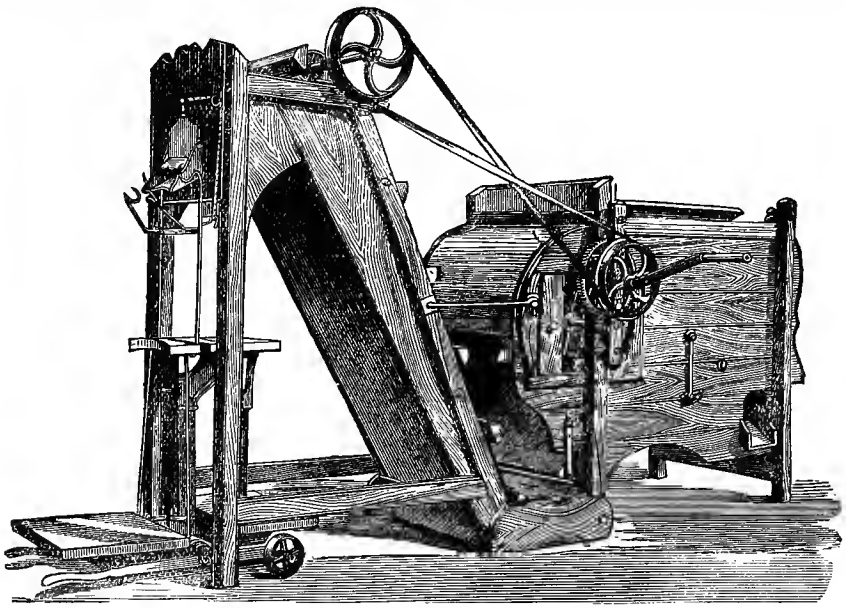


Fig. 515.—*Combined winnower and bagging-machine.*

Very thoroughly most of these modern dressers do their work, yet many farmers still adhere to the custom of putting the grain once through a separate winnower after leaving the threshing-machine. In some cases arrangements are made whereby the grain as it leaves the elevator, raising it from the threshing-machine as at *z'* in fig. 505, falls into the hopper of a winnower, which is worked by hand, and which remains in the granary to give the grain its finishing touches.

In fig. 515 a representation is given of an improved corn-dressing machine, with apparatus attached, for bagging and weighing the grain automatically, made

by T. Corbett, Shrewsbury. The elevator is worked by a strap from the driving-wheel spindle of winnower, and raises the grain by conducting tins, as it passes from the machine, into a hopper, sufficiently high to apply a bag at full length. Under the spout is an ordinary weighing-machine, to which a cord passes from a catch applied in the elevator spout, so that when the bag (which is placed on the weighing-machine) has its proper weight, the descent of the machine disengages the catch, and the slide falls instantly, and thereby prevents a further discharge. The hopper is sufficiently large to receive the grain while the attendant is moving the bag and applying another, by which arrangement the laborious work of filling the bag from the machine is dispensed with, and at the same time a saving of two men is effected. The grain may be elevated at the rate of from 60 to 80 bushels per hour, with wonderfully little difference in the power required to work the winnower.

Many of the improved modern winnowing-machines are so constructed that by change of riddles, screens, &c., all kinds of grass as well as grain seeds can be cleaned by them. Notwithstanding their more varied accomplishments, the modern corn-dressing machines are easier to work than the simple and less efficient but clumsier machines of former times.

Corn-screens. — Screens of various patterns are often used in addition to winnowers in dressing and finishing grain. By these screens sand and dust are thoroughly removed, and small seeds are separated from those of the proper size. Screening is specially serviceable in dressing barley for malting purposes, uniformity of the size of the grain being an element of some importance in the manufacture of malt. Some of these screens are made on the flat, and others on the rotary, principle.

Barn Implements.—There is less use now than formerly for such appliances as riddles, *wechts* or *maunds*, and shovels, in the corn-barn. In former times hand-riddles played an important part in the cleaning of grain, but they have been almost entirely supplanted by improvements in the threshing and dressing machines. The riddling of the corn was heavy and tedious work; and altogether there are few branches of farm-work in which there has been greater saving of

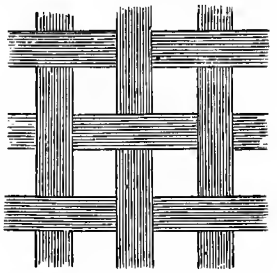


Fig. 516.—*Old wooden wheat-riddle.*

manual labour through the introduction of improved mechanical contrivances

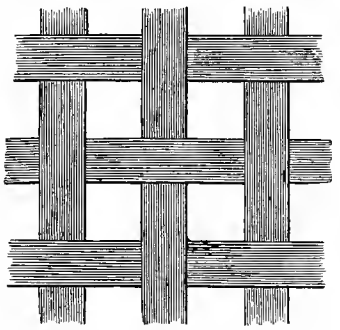


Fig. 517.—*Old wooden barley-riddle.*

than in the threshing, dressing, and handling of grain.

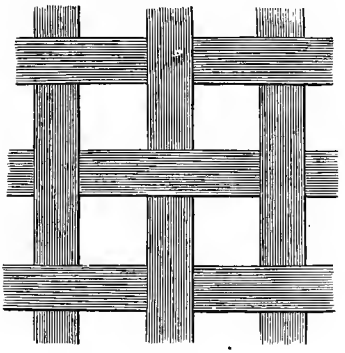


Fig. 518.—*Old wooden oat-riddle.*

Riddles. — Although they are now little used, it may be interesting to preserve here some of the illustrations of

the barn implements in use in former times, and illustrated in previous editions of this work. (See figs. 516 to 520.) In earlier times riddles were, as a rule, made of wood, but latterly wire came to be extensively used. In the illustrations the meshes are shown at full size, and the diameter of the riddle was usually

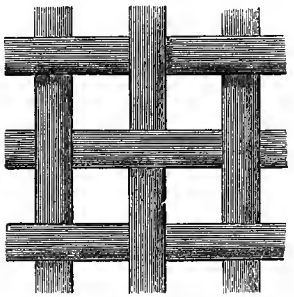


Fig. 519.—*Old wooden bean-riddle.*

about 23 or 24 inches. The mesh for wheat was ¼ inch square, for barley and beans $\frac{5}{16}$ inch, and for oats ⅜ inch;

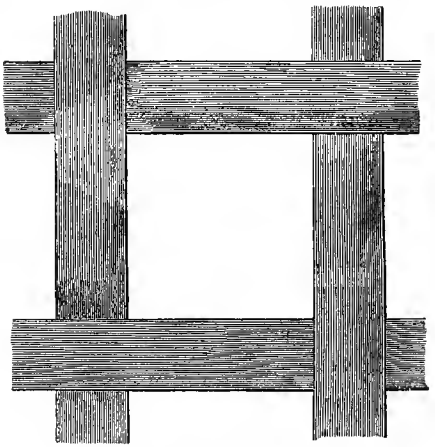


Fig. 520.—*Old wooden riddle for the roughs of wheat and corn.*

while for riddling the roughs of wheat and oats a riddle with meshes of 1 inch square was employed.

Sieves.—The use of the sieves was to sift out dust, earth, and small seeds from corn. The wooden sieve, fig. 521, had meshes of ⅛ inch square, and the iron-wire sieve, fig. 522, 64 meshes to the square inch, including the thickness of the wire. Fig. 523 is a triangular-meshed iron-wire sieve, with an oak rim.

Barn Wechts or Baskets.—A form of *wecht* or *maund* long in use for taking

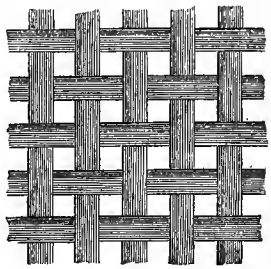


Fig. 521.—*Wooden sieve.*

up corn from the bin or floor is represented in fig. 524, made either of withes or of skin, attached to a rim of wood. A young calf's skin with the hair on, or sheep's skin without the wool, tacked to the rim in a wet state, after becoming dry and hard, makes a better and more durable wecht than wood. Baskets of close and beautiful wicker-work, such as fig. 525, have been used in barns in parts of England instead of wechts.

Fig. 522.—*Iron-wire sieve.*

The articles for lifting the loose corn, either for pouring into the bushel, the bag, or the winnower, are now usually made of wood, almost square, with a deep frame at three sides; and these are much more expeditious than the older forms.

Barn-hoe.—A *wooden hoe*, fig. 526, 7 inches long and 4 inches deep in the

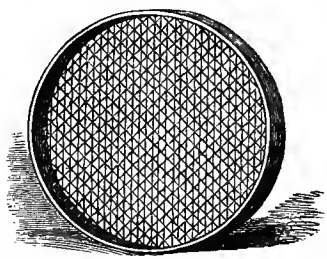


Fig. 523.—*Triangular-meshed iron-wire sieve.*

blade, fixed to a shaft 9 inches long, made of plane-tree, is better than the hands to fill wechts with corn from the floor.

Corn-shovels.—A couple of wooden *scoops* or shovels, such as fig. 527, to shovel up the corn in heaps, and to turn it over, are indispensable implements in a corn-barn.

Barn-brooms.—Excellent brooms for

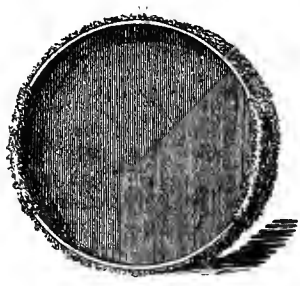


Fig. 524.—*Wecht of skin.*

the corn-barn and granaries are made of stems of the broom plant, about 3 feet in length, simply tied together with twine at one end, and used without a handle. The broom is also in the best

Fig. 525.—*Corn-basket of wicker-work.*

state when fresh, and becomes too brittle when dry. When long straight stems of the common ling (*Calluna vulgaris*) can be procured, they make both good and durable brooms. A hard birch-broom is required to clear the dirt from between the stones of a causeway, while the softer broom answers best for the barn-floor.

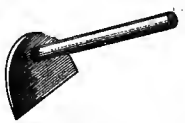


Fig. 526.—*Barn wooden hoe.*

Measuring Grain.—Corn is now invariably measured by the imperial bushel, fig. 528. It is of cooper-work, made of oak and hooped with iron; and, according to the Weights and Measures Act, must be stamped by competent authority before it can be legally used. Having been declared the standard measure of capacity in the country for dry measure, it forms the basis of all contracts dependent on measures of capacity when otherwise indefinitely expressed. The bushel must contain just 2218.19 cubic inches, though its form may vary. The form represented in this figure is somewhat broader at the base than at the top, and furnished with two fixed handles. It is not too broad for the mouth of an ordinary half-quarter sack, nor too deep to compress the grain too much; and its two handles are placed pretty high, so that it may be carried full without the risk of overturning.

Fig. 527.—*Wooden corn-scoop.*

In connection with the bushel is the *strike* for sweeping off the superfluous corn above the edge of the bushel. It is made

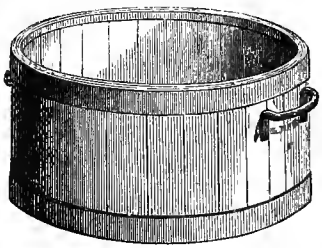


Fig. 528.—*Imperial bushel of a convenient form.*

of two forms—one a flat piece of wood, the other a roller (fig. 529). The

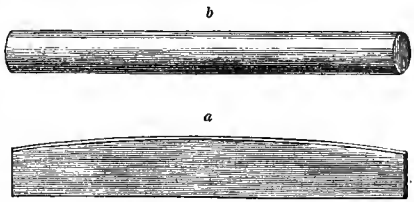


Fig. 529.—*Corn-strikes.*

a Flat corn-strike. *b* Cylindrical corn-strike.

Weights and Measures Act prescribes that the strike shall be round, of light wood, 2 inches in diameter; but many

maintain that the flat strike is best fitted for the purpose.

Bagging Grain. — As already indicated, a great deal of grain is now run into bags or sacks right from the threshing and finishing machine, or from a detached dressing-machine; but in former times the universal practice was to fill sacks by the use of hand wechts or baskets.

Some care is required in measuring corn. The basketfuls should be poured into the bushel from a small height, the higher fall compressing more grains into the bushel. The bushel should be striked immediately after it is filled. The corn raised in the centre of the bushel by the pouring should be levelled lightly with a wave of the fingers of the left hand, not lower than the edge of the bushel farthest from the heap, and sweeping the edge clear of corn, the strike is applied to make the superfluous corn fall off near the heap.

Formerly, the almost universal custom was to put exactly four bushels into each bag and ascertain the weight of the grain by weighing two or three bushels taken from the body of the heap of grain. Now, grain is more frequently bagged and sold by weight than by measurement, the quantity sometimes reduced or measured, according to whether it is unusually heavy or exceptionally light, to bring it to the standard weight of four bushels. The standard weights of the different kinds of grain vary throughout the country—oats from 38 to 42, barley about 54, and wheat 60 or 62 lb., per bushel.

Hummellers. — Wheat and oats are dressed clean by the winnower; but it is otherwise, at times, with barley. When barley has not been thoroughly ripened, the awns are broken off at a distance from the grain by the threshing-machine; and as the part left must be got rid of before the corn can be clean dressed, a *hummeller* is used for the purpose. Improved modern threshing-machines are provided with hummellers, so that barley as well as oats and wheat is threshed and dressed at the one operation. The hummellers in use are of various patterns; and besides those worked in conjunction with threshing-machines, there are hummellers which work separately.

The hand-hummellers are now seldom used, except on small holdings. A very simple form of hand-hummeller is shown in fig. 530. It consists of a square frame of iron, 12 inches each way, 2 inches in depth, and ⅛ inch thick. Bars of similar dimensions are riveted into the sides of the frame, and crossing each other, form compartments of from 1½ to 2 inches square. Such hummellers are also made with parallel bars only, in which case they are less expensive but much less effective. The hummeller is used with a mincing motion on a thin layer of barley on the floor.

Fig. 530.—*Simple hand-hummeller.*

Tying Sacks of Corn. — Filled sacks wheeled aside should have their mouths flat-folded. On tying sacks, which they must be when intended to be sent away by cart, the tying should be made as near the corn as possible, so as to keep the sack firm.

Lifting Sacks of Corn.—There are four modes of lifting a sack to a man's back. One is, for the man to bow his head low down in front of the sack, bending his left arm behind his back, across his loins, and his right hand upon his right knee. Two persons assist in raising the sack, by standing face to face, one on each side of it, bowing down and clasping hands across the sack near its bottom, below the carrier's head, and thrusting the fingers of the other hands into its corners. Each lifter then presses his shoulder against the edge of the sack, and with a combined action upwards, which the carrier seconds by raising his body up, the bottom of the sack is placed uppermost, and the tied mouth downmost, the sack resting upon the back of the carrier. The lifters leaving hold, the carrier keeps the sack steady

on his back, with his left arm across its mouth.

Another plan is, for the carrier to lay hold of the top of the shoulder of the sack with both hands and crossed arms. His two assistants do as directed before; and while they lift the sack between them, the carrier quickly turns his back

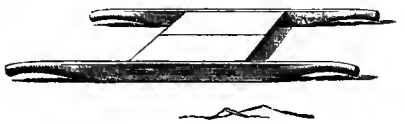


Fig. 531.—*Sack-lifter.*

round to the sack and receives it there, retaining a firm hold of all the parts he had at first.

A third plan is for the assistants to lift the sack upon another one, and the carrier lowers his back down against the side of the sack, laying hold of its shoulders over his own shoulders, when he is assisted in rising up straight with it on his back. A fourth plan, and by far the easiest, is with a sack-lifter, of which there are different patterns. A simple form of sack-lifter is shown in fig. 531. On using it, the sack is lifted upon the board; two assistants, taking hold of the handles, lift it up simultaneously, while

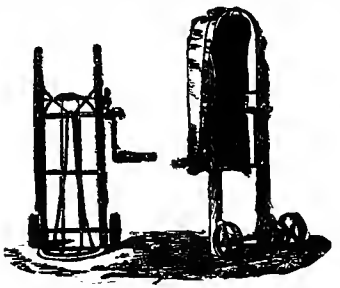


Fig. 532.—*Combined sack-barrow and lifter.*

the carrier turns his back to the load to receive it.

An improved and very convenient sack-lifter is shown in fig. 532. This is a combined sack-barrow and sack-lifter, made by Clayton & Shuttleworth. The barrow is pushed below the sack in the usual way, and then, by the handle shown, the bag is screwed up sufficiently high to enable a man to take it easily on to his back.

The more upright a man walks with a loaded sack on his back, with a short firm step, the less will he feel the weight of the load.

Loading a Cart with Sacks.—In regard to loading a cart with filled sacks, the general principle is to place all the mouths of the sacks within the body of the cart, that should any of the tyings give way, the corn will not be spilled upon the ground. Two sacks are laid flat on the bottom of the cart, with the mouths next the horse. Two are placed with their bottoms on the front; two on the tail-board, with their bottoms in the rear; other two on edge above

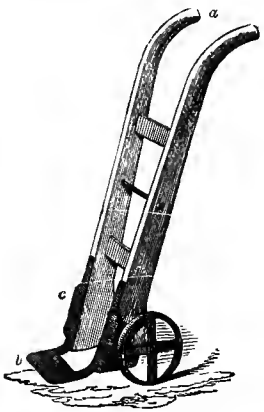


Fig. 533.—*Sack-barrow.*

a Handle. *b* Shelf.
c Shields over wheels.

these four; and one behind, on its side, with the mouths of all three pointing inwards.

Corn-sacks.—The sacks for corn require attention to keep them serviceable. They are usually made of tow yarn, manufactured, tweeled, or plain. The ties for tying the mouth of the sack when it is full should be fastened to the seam of the sack. Every sack should be marked with the initials of the owner's name, or the name of the farm, or with both. The letters are best painted on with a brush, rubbing the paint upon open letters cut through a plate of zinc.

When sacks become wetted with rain they should be shaken and hung up to dry; and if dirtied with mud, they should

be washed and dried. If the air in winter, when sacks are most used, cannot dry them in time to prevent mouldiness, they should be dried before a fire. Where steam is used for threshing, sacks may be dried in the boiler-house. An airy place to keep sacks is across the granary, over ropes suspended between the legs of the couples.

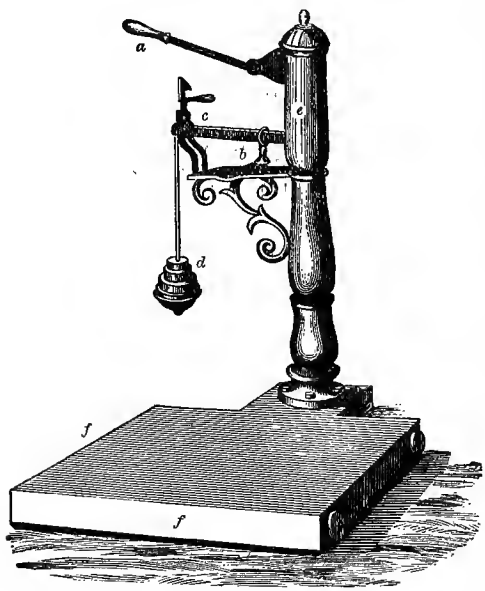


Fig. 534.—*Portable weighing-machine.*

a Lever. *d* Weight-plate. *f f* Platform.
c Balance. *b* Sliding-weight. *e* Standard.

The best thread for darning even canvas sacks is strong worsted. When a sack is much torn, it may be used to patch others with. The person who has the charge of threshing and cleaning the corn has also the charge of the sacks, and must be accountable for their number.

Sack-barrow.—Sacks, filled, are most easily moved about by a sack-barrow, fig. 533—see also fig. 532. The height of the barrow in fig. 533 is 3½ feet, and breadth across the wheels 1½ foot.

Weighing-machines.—A weighing-machine is an important article of barn furniture, and various forms of it are resorted to. The common beam and scales is the most correct of all the instruments of the class; but it is defective, as being less convenient for the purposes of the barn than several others that are partially employed. Steelyards of various forms are also used.

Fig. 534 is a perspective view of a portable lever weighing-machine, extensively used. When the lever of the standard is up, as in the figure, any weight placed on the platform does not affect the balance-beam; but on pulling it down, it puts the platform in connection with the beam. Weights are then put on the weight-plate connected by a rod with the extremity of the balance-beam, these weights representing cwts. and imperial stones. The balance-beam is divided into parts, each showing a pound, from 1 to 14 lb. After bringing this beam nearly to the balance-level, the sliding-weight is moved along it till the balance is accurately obtained. The weights on the weight-plate show the number of cwts. and stones, and the sliding-weight indicates on the scale of the beam the number of pounds beyond the cwts. and stones. The article to be weighed is placed on the platform.

GRASSES AND CLOVERS.

VARIETIES OF GRASSES.

The grasses all belong to the natural order *Gramineæ*. Those varieties which are principally used in agriculture are detailed below. For the descriptions of them we are indebted to Mr Martin J. Sutton, the author of the well-known work on *Permanent and Temporary Pastures*.

Agrostis alba—*var.* stolonifera.

(Fiorin, or Creeping Bent Grass.)

Fr. *Agrostide blanche stolonifère.* Ger. *Fioringras.*

Roots creeping, rootstock perennial and stoloniferous. Stems 6 inches to 3 feet. Leaves numerous, flat, and usually scabrid; sheath rough; ligule long and acute. Panicle spreading, with whorled branches. Spikelets one-flowered, small. Empty glumes larger than flowering glumes, unequal, smooth, and awnless. Flowering glumes slightly hairy at the base, with occasionally a minute awn. Palea minute and cloven at the point. Flowers from July to September. Grows in pastures and damp places throughout Europe, Siberia, North Africa, and North America (fig. 535).

Although none of the creeping bent grasses are considered particularly nutritious for cattle, yet this variety is sometimes desirable in permanent mixtures, in consequence of its value in affording herbage early in spring and late in autumn, before and after other grasses

Fig. 535.—Fiorin, or creeping bent grass (*Agrostis alba*, var. *stolonifera*).

have commenced or left off growing. Its long fibrous roots and creeping habit are naturally adapted for moist situations.

Alopecurus pratensis.

(Meadow Foxtail.)

Fr. *Vulpin des prés.* Ger. *Wiesen Fuchsschwanz.*

Roots fibrous, rootstock perennial. Stems 1 to 3 feet, erect and smooth. Leaves flat and broad; sheath smooth and longer than its leaf; ligule large and truncate. Panicle spike-like, cylindrical, and obtuse. Spikelets one-flowered, and laterally compressed. Empty glumes larger than flowering glumes, hairy on the keel, awnless. Flowering glumes with straight awn inserted at the middle of the back. Palea none. Flowers from the middle of April to June. Grows in meadows and pastures throughout Europe, North Africa, Siberia, and North-western India (fig. 536).

Meadow foxtail is one of the earliest and best grasses for permanent meadows and pastures, and may also with advan-

Fig. 536.—Meadow foxtail (*Alopecurus pratensis*).

tage be included in mixtures for 3 or 4 years' lea. It furnishes a large quantity of nutritive herbage, produces an abundant aftermath, and is eagerly eaten by all kinds of stock. The leaves are broad and of dark-green colour. The habit is somewhat coarse, hence it is unfit for lawns or bowling-greens, but its very early growth recommends it as eminently suitable for ornamental park purposes. It succeeds best on well-drained, rich, loamy, and clay soils, makes excellent hay, and should be included in a larger or smaller proportion in most mixtures for permanent pasture. Meadow foxtail is admirably adapted for irrigation. It also flourishes under trees, and should be sown plentifully in orchards and shaded pastures.

Anthoxanthum odoratum.

(Sweet-scented Vernal.)

Fr. *Flouve odorante.* Ger. *Gemeines Ruchgras.*

Roots fibrous, rootstock perennial. Stems 1 to 2 feet, tufted, erect, glabrous, and with few joints. Leaves hairy, flat, and pointed;

sheath ribbed and slightly hairy; ligule hairy. Panicle spike-like, pointed at summit, uneven below. Spikelets one-flowered, lanceolate. Empty glumes in two pairs; outer two much larger than the flowering glumes, unequal, hairy at the keels and pointed at the ends, awnless; second pair shorter and narrower than first pair, equal; also hairy and both awned, one with short straight awn inserted at the back near the summit, the other with long bent awn inserted at the centre of the back. Flowering glumes small, glabrous, and awnless. Palea adherent to the seed. Stamens two. Anthers large. Flowers April and May. Grows in fields, woods, and on banks throughout Europe, Siberia, and North Africa (fig. 537).

To the presence of this grass our summer hay-fields owe so much of their fragrance that it should be included in all

Fig. 537.—Sweet-scented vernal (*Anthoxanthum odoratum*).

mixtures for permanent meadow or hay. The scent is less distinguishable in a fresh than in a dried state, but its very pleasant taste, somewhat resembling highly flavoured tea, is discernible at all stages of its growth. In point of productiveness this grass is inferior to foxtail, cocksfoot, and other strong-growing varieties; but the quality is excellent, the growth very early, and the plant continues to throw up flowering stalks till quite late in the autumn. On account of the broad foliage, this grass is ill adapted for grounds where short grass is indispensable; but for parks and pleasure-grounds it is especially suitable, on account of its bright green colour. Pastures in which this grass abounds naturally produce the finest mutton; and, both in a young state and when mixed with other varieties, it is much relished by cattle and horses. It is valuable in hay, as its flavour enhances the price, and it also yields a good quantity of feed after the hay crop is cut. It constitutes a part of the herbage on almost every kind of soil, particularly on such as are deep and moist.

Avena flavescens.

(Yellow Oat-grass.)

Fr. *Avoine jaune.* Ger. *Goldhafer.*

Rootstock perennial, creeping, and somewhat stoloniferous. Stems 1 to 2 feet, erect, glabrous, and striated. Leaves flat; radical leaves and sheaths hairy; ligule truncate and ciliated. Panicle spreading, with many branches, broad at the base and pointed at the summit. Spikelets three- or four-flowered, small, shining, and of a bright yellow colour. Empty glumes unequal, keeled, and rough. Flowering glumes hairy at the base and toothed at summit, with slender twisted awn springing from below the middle of the back. Palea narrow, short, and blunt. Flowers June, July, and August. Grows in pastures throughout Europe, North Africa, and Asia (fig. 538).

This grass may easily be discerned in July by its bright golden cluster of flowers, and is among the latest varieties in coming to maturity. The leaves are of a pale-green colour, hairy, and al-

Fig. 538.—Yellow oat-grass (*Avena flavescens*).

though they are not produced in great abundance, are much relished by cattle. It affords sweet hay, and yields a considerable bulk of fine herbage. After

the crop is cut for hay, a large aftermath is produced. This grass thrives on calcareous land, and in the Thames Valley it contributes no inconsiderable portion of the herbage of the water meadows.

Avena elatior.

(Holcus avenaceus ; Arrhenatherum avenaceum.) (Tall Oat-grass.)

Fr. *Arrhénathère élevée.* Ger. *Hoher Wiesenhafer.*

Rootstock perennial, widely creeping. Stems 2 to 4 feet, erect and smooth; leaves scabrid and flat; sheath smooth; ligule short and truncate. Panicle erect and sometimes slightly nodding at the apex, widely spreading during flowering, closed before and after. Spikelets two-flowered. Empty glumes unequal and pointed. Flowering glumes two, the lower with long twisted awn, the upper with short straight awn. Flowers June and July. Grows in meadows and pastures throughout Europe, Africa, Asia, and America.

A strong-growing and rather coarse grass of good feeding quality. The flavour is slightly bitter, and on this account cattle do not at first manifest a liking for it, but when mingled with other grasses the objectionable characteristic is imperceptible. Although this plant is classed among perennials, it cannot be relied on as strictly permanent, and therefore we do not advise its employment for a longer period than three or four years. For alternate husbandry, however, it may be freely sown among other grasses, and its presence will augment the weight of the crop. On poor thin land tall oat-grass is useless, but on drained clays and rich soils generally it grows luxuriantly. The plant is a gross feeder, and must be liberally treated to bring it to perfection. The seed needs to be buried more deeply than is safe with other grasses.

Cynosurus cristatus.

(Crested Dogstail.)

Fr. *Cynosure crêtelle.* Ger. *Kammgras.*

Rootstock perennial, stoloniferous. Stems 1 to 2 feet, tufted, erect, smooth, and wiry. Leaves very narrow, ribbed, slightly hairy; sheath smooth; ligule short and bifid. Panicle spike-like, secund. Spikelets many-flowered, ovate, flat, with a barren spikelet consisting of empty glumes arranged in a pectinate manner at the base. Empty glumes sharply pointed, shorter than flowering glumes, unequal, with prominent rough keels. Flowering glumes lanceolate, with short awn at summit. Palea very thin, slightly ciliated. Flowers July and August. Grows in dry hilly pastures throughout Europe, Western Asia, and North Africa (fig. 539).

Crested dogstail is a fine short grass, and constitutes a considerable portion of the herbage of sheep-walks and deer-parks. It is found in most meadows and pastures used for grazing. Sinclair describes it as forming "a close dense turf of grateful nutritive herbage, and is little affected by extremes of weather." From our own experience

Fig. 539.—Crested dogstail (*Cynosurus cristatus*).

and observation, we can fully indorse the opinion of this eminent authority, and recommend its being included in all best permanent mixtures. We have especially noticed the beneficial results obtained by its use with other grasses in sheep-pastures; and it is generally believed that sheep fed on pastures containing dogstail are less liable to foot-rot than when fed on pastures composed of the more soft-leaved varieties. On account of its close-growing habit and evergreen foliage, it is particularly valuable for lawns, pleasure-grounds, and other places kept under by the scythe.

Dactylis glomerata.

(Rough Cocksfoot.)

Fr. *Dactyle glomérè.* Ger. *Gemeines Knaulgras.*

Roots fibrous, rootstock perennial. Stems 2 to 3 feet, erect, stout, and smooth. Leaves

broad, keeled, and rough; sheath scabrid; ligule long. Panicle secund, spreading below, close and pointed above. Spikelets three- to five-flowered, laterally compressed, and closely clustered at the end of the branches. Empty glumes smaller than flowering glumes, unequal, keeled, and hairy on upper part of the keel, pointed at the summit. Flowering glumes with hairy keel, pointed and ending in a short awn. Palea bifid at summit, and fringed at base. Flowers June and July. Grows in pastures, woods, orchards, and waste places throughout Europe, North Africa, North India, and Siberia (fig. 540).

This well-known grass grows luxuriantly in deep rich soils and low-lying meadows. For the enormous quantity

Fig. 540.—Rough cocksfoot (*Dactylis glomerata*).

of produce it yields, the rapidity with which it shoots forth again after having been eaten or cut, and also for the important fact of its being so much relished by horses and cattle, it is eminently suitable for sowing with other quick-growing grasses for alternate husbandry. It should be included in permanent mixtures for tenacious soils and damp situations; but in parks and ornamental grounds its tufty habit of growth renders it inadmissible. It withstands drought well, and succeeds under trees, &c. It is very useful for sowing in covers, if allowed to grow without checking.

Festuca pratensis.

(Meadow Fescue.)

Fr. *Fétuque de prés.* Ger. *Wiesen Schwingel.*

Rootstock perennial. Stems 18 inches to 3 feet, tufted, erect, and smooth. Leaves flat and smooth; sheath smooth; ligule short. Panicle spreading, but closer and narrower than in *F. elatior*, with fewer branches. Spikelets many-flowered, lanceolate. Empty glumes shorter than flowering glumes, unequal and acute. Flowering glumes rough, and slightly awned. Palea acute and ribbed, with hairy nerves. Flowers June and July. Grows on good pastures throughout Europe and Northern Asia (fig. 541).

One of the earliest, most nutritious, and productive of our natural grasses. Both in its green and dried state it is eagerly eaten by all kinds of stock. It is useful for 3 or 4 years' leas, but is especially suitable for permanent pasture purposes. It is more adapted for moist than dry soils; still it constitutes a considerable portion of the herbage of all high-class pastures. Meadow fescue is thus referred to by Commander Mayne, in his *Four Years in British Columbia and Vancouver's Island:* "Cattle and horses are very fond of *F. pratensis*, or sweet grass, and it has a wonderful effect in fattening them. I have seen horses on Vancouver's Island, where the same grass grows, which had been turned out

Fig. 541.—Meadow fescue (*Festuca pratensis*).

in the autumn, brought in in April in splendid condition, and as fresh as if they had been most carefully treated all the time." Although particularly robust

in habit, it never grows in large tufts, as is the case with some coarse-growing grasses. The hay from it is plentiful, and of excellent quality.

Festuca elatior.

(Tall Fescue.)

Fr. *Fétuque élevée.* Ger. *Hoher Schwingel.*

Rootstock perennial, somewhat stoloniferous. Stems 3 to 6 feet, erect and smooth. Leaves broad, flat, and scaberulous; sheath smooth; ligule short. Panicle diffuse and nodding.

Fig. 542.—Tall fescue (*Festuca elatior*, var. *fertilis*).

Spikelets many-flowered, half an inch long or more, lanceolate. Empty glumes shorter than flowering glumes, acute and unequal. Flowering glumes broad, rough, and toothed at the apex. Palea acute and ribbed, with hairy nerves. Flowers June and July. Grows in damp pastures and wet places throughout Europe, North Africa, and North America (fig. 542).

Some botanists consider the *F. elatior* and the *F. pratensis* to be identical, and these grasses are consequently to be found in many botanical works bracketed together as synonymous. There is, however, a decided difference, which is clearly manifest not only in the seed, but in the growth of the two varieties. The seed of the true *F. elatior* is broader and longer than that of *F. pratensis*. The growth, too, is more robust, of much greater size in every respect, and it will consequently produce a heavier bulk of hay or feed. The panicles also of the *F. elatior* are quite distinct from those of the *F. pratensis*, being branched, bent, and drooping, and composed of large clusters. Those of the *F. pratensis*, on the contrary, are decidedly upright in their early stages of growth, becoming slightly bent as the flower approaches maturity. On account of its luxuriant habit, we do not recommend the use of *F. elatior* where a fine turf is required; yet as a productive grass, and one which is greedily eaten by stock, it may form a part of permanent mixtures for moist and strong soils where the crop is intended for grazing, and also for irrigation purposes. It is admirably adapted for covers, in which its large seeds are useful as food.

Festuca heterophylla.

(Various-leaved Fescue.)

Fr. *Fétuque feuilles variées.*
Ger. *Wechselblätteriger Schwingel.*

Roots fibrous, rootstock perennial, tufted. Stems 2 to 2½ feet, numerous, erect, and smooth. Leaves various, dark green, lower ones folded triangular, upper ones flat. Ligule almost obsolete. Panicle diffuse. Spikelets many-flowered. Empty glumes unequal, shorter than flowering glumes, with prominent midrib and long awn. Flowers June and July. Grows in meadows and pastures throughout Central Europe; introduced into Great Britain for cultivation in permanent pastures.

This species is a native of France, where it is extensively grown, and was introduced to England in 1814. It is well adapted to our climate, and is valuable for parks and ornamental grounds, for its beautiful dark-green foliage. It is also particularly suited to pastures, on account of its large bulk of herbage; but it produces little feed the same season after mowing.

Festuca ovina tenuifolia.

(Fine-leaved Sheep's Fescue.)

Fr. *Fétuque des brebis.* Ger. *Schaf Schwingel.*

Rootstock perennial, tufted. Stems 6 to 12 inches, erect, and densely tufted, rough at the upper part and smooth below. Leaves very slender, chiefly radical, upper ones rolled; sheath smooth; ligule long and bilobed. Panicle small, erect, contracted, and subsecund. Spikelets many-flowered, small, upright. Empty glumes shorter than flowering glumes, unequal, and acute. Flowering glumes small, with minute awn. Palea toothed, with hairy nerves. Flowers June and July. Grows in dry, hilly pastures throughout Europe, Siberia, North Africa, North America, and Australia (fig. 543).

This grass is supposed to have received its specific name from Linnæus, on account of its being so much relished by

Fig. 543.—Sheep's fescue (*Festuca ovina*).

sheep; and Gmelin, the eminent Russian botanist, says that the Tartars generally pitch their tents during the summer months in close proximity to it, on account of its value to their herds. There is no question but that on good upland pastures, especially if used for sheep grazing, this grass should form a large proportion of the herbage. In produce it is inferior to some others, but deficiency in quantity is more than counterbalanced by its excellent nutritive qualities. From its remarkably fine foliage it is particularly suited for lawns and pleasure-grounds, which are constantly mown.

Festuca duriuscula.

(Hard Fescue.)

Fr. *Fétuque durette.* Ger. *Harter Schwingel.*

Rootstock perennial, slightly creeping. Stems 1 to 2 feet, erect, and tufted, but less so than in *F. ovina tenuifolia.* Stem-leaves flat, lanceolate, and striated; sheath downy; ligule almost or entirely obsolete. Panicle erect and spreading when in flower. Spikelets many-flowered, and larger than in *F. ovina tenuifolia.* Empty glumes lanceolate and unequal. Flowering glumes narrow, with a short awn. Palea toothed, with hairy nerves. Flowers June and July. Grows in hilly places throughout Europe, North Africa, Siberia, North America, and Australia (fig. 544).

This is one of the most valuable and important of the smaller fescues, and its presence in hay is generally indicative of superior quality. It comes very early, retains its verdure during long-continued drought in a remarkable manner, and is one of the best of pasture grasses. All kinds of stock eat it with avidity, but especially sheep, which always thrive well on the succulent herbage it produces.

Fig. 544.—Hard fescue (*Festuca duriuscula*).

From the fineness of its foliage, and the fact of its resisting the drought of summer and cold in winter, it is eminently adapted for sowing in parks and ornamental grounds. A large quantity of food is produced after the grass is cut for hay.

Festuca rubra.

(Red Fescue.)

Fr. *Fétuque rouge.* Ger. *Rother Schwingel.*

Rootstock perennial, with long creeping stolons. Stems erect, 2 to 3 feet. Leaves flat and rolled; sheath hairy; ligule long. Panicle spreading, and slightly drooping at apex. Spikelets many-flowered, of a reddish colour. Empty glumes unequal. Flowering glumes

lanceolate, with a short awn. Flowers June and July. Grows in dry low-lying places near the sea, throughout Europe, North Africa, Siberia, and North America.

Although this grass is considered by some to be merely a variety of *F. duriuscula*, altered in habit by frequent cultivation on dry soil, yet to the careful observer there will appear an appreciable difference between the two varieties. The leaves are broader, of darker colour than the *F. duriuscula*, while the growth is more robust. The principal difference, however, is in the creeping habit of *F. rubra*, which enables it to live on loose, light, dry soils, where most other grasses fail. Its creeping roots penetrate so deeply into the soil, as to enable the plant to maintain a fresh and green appearance when other varieties are burnt up. It is particularly adapted for pastures by the seaside. The leaves and stems are more nutritious, and of superior bulk, at the time of ripening seed than earlier in the season.

Glyceria fluitans.

(Floating Sweet Grass.)

Syns.—POA FLUITANS and FESTUCA FLUITANS.

Fr. *Glycérie flottante.* Ger. *Schwimmgras.*

Rootstock perennial, stoloniferous. Stems branched, floating or creeping, stout and smooth. Leaves short, flat, and broad; ligule long, broad and pointed at apex. Panicle erect and branching. Spikelets oblong and many-flowered. Empty glumes unequal, flowering glumes scabrid, and blunt at apex. Palea with ciliated nerves. Flowers July and August. Grows in damp places throughout Europe, Siberia, North Africa, and North America.

This grass is found growing naturally by the sides of ditches, pools, lakes, and rivers, and is perhaps the only water-grass which is eaten with avidity by both sheep and cattle. The leaves are narrow, of a pale green colour, and succulent. It is valuable for moist situations, and thrives especially in the Fen districts.

Lolium perenne.

(Perennial Rye-grass.)

Fr. *Ivraie vivace.* Ger. *Englisches Raygras.*

Roots fibrous, rootstock perennial, sometimes stoloniferous. Stems 1 to 2 feet, bent at the base, ascending, smooth, and slightly compressed. Leaves flat, narrow, and obtuse; edges and upper surface scabrid; sheath smooth and compressed; ligule short and blunt. Panicle spiked. Spikelets many-flowered, solitary, sessile, distichous. Empty glumes, only an outer one to each spikelet, except in the case of the upper spikelet, which has two, lanceolate, smooth, distinctly ribbed, and shorter than the spikelets. Flowering glumes obtuse, ribbed, and with sometimes a minute awn. Flowers May and June (fig. 545).

In the year 1882 a warm discussion arose as to the character and value of rye-grass, and the part which it should play in the formation of permanent and temporary pastures, the former in particular. In that year the late Mr C. D. L. Faunce

Fig. 545.—Perennial rye-grass (*Lolium perenne*).

de Laune of Sharsted Court, Sittingbourne, contributed a paper to the *Journal of the Royal Agricultural Society of England* (vol. xviii., sec. ser., part 1) "On Laying Down Land to Permanent Grass." There he condemned rye-grass, and urged "the necessity of eliminating" it from all mixtures of seeds to be sown in the formation of permanent pastures. In the same publication and through other channels he continued his denunciation of rye-grass, stating that—"My observations lead me to believe that rye-grass is detrimental to the formation of new pasture, not only because it is a short-lived grass, but because, owing to the shortness of its roots, it exhausts the

surface of the soil; and when it dies, the bare space left is so impoverished that, though grass seeds may germinate upon it, they fail to live unless highly manured by accident or on purpose."[1]

Mr de Laune certainly formed excellent permanent pastures without the assistance of rye-grass, and it cannot be denied that some good resulted from the discussion which he aroused. It was well known that farmers did not then, as a rule, give sufficient attention to the selection of seeds for pastures, and it is also more than probable that rye-grasses sometimes bulked more largely in seed-mixtures than was desirable.

Mr W. Carruthers, consulting botanist to the Royal Agricultural Society, joined with Mr de Laune in the controversy, in so far as to contend that rye-grass is no more perennial than the wheat plant; that it would die out in two years unless kept free from seeding; and that it should therefore be excluded from permanent pastures. But he recommended rye-grass for temporary pastures, and admits that if it were eaten close down and not allowed to seed, "they might keep it alive as long as they like."

But the attack upon rye-grass did not long prevail. It was successfully repelled by the late Dr Fream, the late Sir John B. Lawes, and others, who demonstrated the important and significant fact that rye-grass with white clover form the dominant constituents of many of the finest old pastures in the country, including the celebrated feeding-pastures of Leicestershire. The results of Dr Fream's investigations are recorded in the *Journal of the Royal Agricultural Society*, vol. xlviii., sec. ser., part 2.

There is no thought now of removing rye-grass from its wonted place in grass-seed mixtures, whether for permanent or temporary pastures. As to the relative quantity of rye-grass and other grasses, hard-and-fast rules should not be insisted upon. The quantities we have stated will not suit equally well in all circumstances; and while some may think it well to use still larger quantities of rye-grass, others may perhaps find smaller give better results.

[1] *Jour. Royal Agric. Soc. Eng.*, xviii., sec. ser., part 2.

Lolium italicum.

(Italian Rye-grass.)

Fr. *Ivraie d'Italie.* Ger. *Italienisches Raygras.*

Annual or biennial. Root fibrous. Stems 2 to 4 feet, erect, stout, smooth. Leaves long, broad, glabrous, and succulent; sheaths slightly rough; ligule short and obtuse. Spikelets many-flowered, sessile, distichous on a long rachis. Upper empty glume only present in the terminal spikelet; lower empty glume persistent, lanceolate, obtuse, scarcely reaching to middle of spikelet. Flowering glumes lanceolate. Awn almost as long as glume. Palea ciliate at base. Flowers June and July. Not known in a wild state (fig. 546).

The Italian rye-grass was introduced into this country in 1831 by the late Charles Lawson. It is very distinct in its character and seed from ordinary rye-

Fig. 546.—Italian rye-grass (*Lolium italicum*).

grass, and as it is not perennial, it is only suitable for alternate husbandry, and producing early feed in the spring for sheep and cattle; but in permanent pastures it is to be avoided entirely. For sewage cultivation it stands in the first rank of all forage plants.

It has produced extraordinary crops at various sewage farms. On account of its rapid growth, and for its succulent herbage, it is invaluable for early sheep feed. It may be sown with safety any time between the months of February and October. If alone, 3 bushels per acre is the quantity required; but if sown on a corn crop with clovers, a much smaller quantity will suffice. In the latter case, it should not be sown until the crop is up. The mode of cultivation is exceedingly simple—harrowing the ground before and after sowing, and rolling subsequently, being all that is required. If the land is in good condition, three or four heavy cuttings per annum may be obtained, even without liquid manure; but undoubtedly, the more manure applied, especially in liquid form, the more abundant the crop; and it is important that the liquid should be applied immediately after cutting.

It is a common notion that wheat will not answer after Italian rye-grass. The following opinion of the late Mr William Dickinson on this point is worth consideration: "Thirty sheep may be kept upon Italian rye-grass, fed through hurdles, upon as little land as ten can be kept upon the common system upon common grass; and the finest crops of wheat, barley, oats, and beans may be grown after the Italian rye-grass has been fed off the two years of its existence. *Wheat invariably follows the Italian—splendid crops are grown where wheat had not been grown before.*"

Phleum pratense.

(Timothy Grass, or Meadow Catstail.)

Fr. *Fléol des prés.* Ger. *Timothygras.*

Rootstock perennial, somewhat creeping. Stems 1 to 3 feet, erect and smooth. Leaves short, flat, and soft; sheath smooth; ligule oblong. Panicle spike-like, cylindrical, elongate, and compact. Spikelets one-flowered, laterally compressed. Empty glumes larger than flowering glumes, equal, each with stiff hairs on the keel and a short scabrid terminal awn. Palea minute and pointed. Flowering glumes much smaller than empty glumes, toothed and awnless. Flowers end of June to August. Grows in meadows and pastures throughout Europe, North Africa, Siberia, and Western Asia (fig. 547).

One of the most common of our meadow plants. In some parts of America it attains a great height, and forms the bulk of the grass hay of that country. In England it is largely cultivated in conjunction with other strong-growing grasses. For early feeding timothy is superior to cocksfoot. It may be pastured for some time through the spring without damage to the hay crop. It succeeds well on soils of a moist and retentive nature, and is keenly relished by all kinds of stock, whether in a green state or made into hay. In addition to its usefulness for permanent pasture, it possesses a high value for alternate husbandry.

Fig. 547.—Timothy (*Phleum pratense*).

Poa pratensis.

(Smooth-stalked Meadow-grass.)

Fr. *Paturin des prés.* Ger. *Wiesen Rispengras.*

Rootstock perennial, creeping and stoloniferous. Stems 1 to 2 feet, erect, smooth, and rather stout. Leaves flat, rather broad and slightly concave at the tip; sheath smooth and longer than its leaf; ligule short and blunt. Panicle loose, spreading and pyramidal in shape. Spikelets three- to five-flowered, compressed. Empty glumes much webbed, lanceolate, almost equal. Flowering glumes larger, webbed, keeled, and acute. Palea short. Flowers June and early in July. Grows in meadows and pastures throughout Europe, Siberia, North Africa, and North America (fig. 548).

This variety in early spring presents a beautiful green appearance, and is easily

distinguished from *Poa trivialis* by its smooth culms and leaves. Being of a more creeping habit than other Poas, it is sometimes condemned as exhausting the soil. On account of its unusual

Fig. 548.—Smooth-stalked meadow-grass (*Poa pratensis*).

earliness and great productiveness at a period of the season when other grasses are comparatively dormant, it should be included in permanent pasture mixtures where early feed is of importance. *Poa pratensis* flourishes in dry soil, makes excellent hay and aftermath, and is valuable for garden lawns and ornamental grounds.

Poa trivialis.

(Rough-stalked Meadow-grass.)

Fr. *Paturin commun.* Ger. *Gemeines Rispengras.*

Rootstock perennial, somewhat creeping, but not stoloniferous. Stems 1 to 2 feet, erect, rough and slender. Leaves flat, narrow, acute, and rough; sheath rough and equal to its leaf; ligule long and pointed. Panicle loose, spreading and pyramidal in shape. Spikelets three- to five-flowered, compressed. Empty glumes webbed, lanceolate, and nearly equal. Flowering glumes keeled and acute. Palea short and slightly fringed. Flowers June to end of July. Grows in meadows and pastures throughout Europe, Siberia, North Africa, and North America (fig. 549).

This grass is somewhat similar in appearance to *P. pratensis*, but the two varieties differ materially in habit and general properties. It will be seen, on referring to the illustrations, that the flower-stems of the *P. pratensis* are slightly drooping in habit, while those of the *P. trivialis* are more erect; that the ligule (or small tongue) of the leaf in the latter is pointed, while in the former it is blunt. *P. trivialis* is adapted for good deep rich moist loams, stiff heavy clays, and irrigated meadows. It is unsuited for dry upland pastures, and if sown in such positions will soon disappear. Opinions differ as to the merits of this grass, some botanists declaring it to be only a second-rate variety. Our own experiments quite confirm Sinclair, who thus refers to it: "The superior produce of this Poa over many other species of grass, its highly nutritive properties, the season at which it arrives at perfection, and the

Fig. 549.—Rough-stalked meadow-grass (*Poa trivialis*).

marked partiality which horses, oxen, and sheep have for it, are merits which distinguish it as one of the most valuable of those grasses which affect rich soil and sheltered situations."

Poa nemoralis sempervirens.

(Hudson's Bay, or Evergreen Meadow-grass.)

Fr. *Paturin des Bois à feuilles persistantes.*
Ger. *Wintergrünes Hain Rispengras.*

Rootstock perennial, slightly creeping, but not stoloniferous. Stems 1 to 3 feet, erect, smooth. Leaves narrow, pointed, rough on the surface and outer edges; sheath smooth; ligule none or very minute. Panicle diffuse, slender, and nodding; spikelets lanceolate, compressed. Empty glumes acute, nearly equal, sometimes slightly webbed. Flower-

ing glumes rather large, lanceolate, with three hairy ribs. Palea with nerves slightly fringed. Flowers June and July. Grows in woods and shady places throughout Europe and Northern Asia (fig. 550).

The great recommendations of this grass are its perpetual greenness, and dwarf, close-growing habit. These qualities, as well as its reproductiveness, render it one of the very best varieties for lawns or pleasure-grounds, and the fact that it thrives under the shade of trees considerably enhances its value. It yields a good bulk of herbage, endures drought, and starts growth early in spring.

Fig. 550.—Evergreen meadow-grass (*Poa nemoralis sempervirens*).

Poa aquatica.

(Water Meadow-grass.)

Fr. *Paturin aquatique.* Ger. *Wasser Rispengras.*

Rootstock perennial, creeping and stoloniferous. Stems erect, smooth, and very stout. Leaves broad, rough, and with prominent ribs; ligule short and truncate; sheath smooth. Panicle spreading, with many branches. Spikelets many-flowered, oblong and compressed. Empty glumes unequal and short. Flowering glumes short, broad, and with prominent nerves. Flowers July and August. Grows in wet places throughout Europe, Siberia, and North America.

Poa aquatica grows luxuriantly in the Fen counties, where it forms a rich pasturage in the summer, and constitutes the chief winter fodder. In districts which are wholly or partially flooded, it is entitled to increased attention. It may be cut three or four times a-year, and produces an immense quantity of herbage on soils which will not grow other grasses. The seed is generally scarce.

VARIETIES OF CLOVERS.

The clovers belong to the natural order *Leguminosæ*, genus *Trifolium*. The generic name is evidently derived from the triple leaves of the plants.

The following are the usually cultivated forms of *Trifolium*:—

Systematic Name.	Common Name.	Colour of Flower-head.
T. incarnatum	"Trifolium"	Crimson.
T. pratense	Meadow clover	Red or purple.
T. hybridum	Alsike	Pink and white.
T. repens	Dutch clover	White.
T. minus	Suckling clover	Yellow.

Importance of the Clovers.—This tribe includes, therefore, the most valuable herbage plants adapted to European agriculture—the white and red clovers. Notwithstanding what has been said of the superiority of *lucerne*, and of the excellence of *sainfoin* in forage and hay, the red clover for mowing, and the white for pasturage, excel, and probably ever will, all other plants.

Soils and Climate for Clovers.—The *soil* best adapted for red clover, *Trifolium pratense*, is deep sandy loam, which is favourable to its roots; but it will grow in any soil, provided it be dry. Marl, lime, or chalk promotes its growth. The *climate* most congenial to it is neither hot, dry, nor cold. Clover produces most seed in a dry soil and warm temperature; but as the production of seed is only in some situations an object of the farmer's attention, a season rather moist, provided it be warm, affords the most bulky crop of herbage.

Clover Seed.—Red-clover seed is imported into Britain from America, Germany, Holland, France, and even Italy, where it is raised as an article of commerce. What has been obtained from the last two countries has been found often too tender to stand an English winter. In Switzerland, clover seed is prepared for sowing by steeping in water or oil, and mixing it with powdered gypsum, as a preventive to the attacks of insects.

Perennial Red Clover.—The perennial red variety — *Trifolium pratense perenne*, or cow-grass (fig. 551)—bears a great resemblance to the biennial in its general habits and appearance, and is

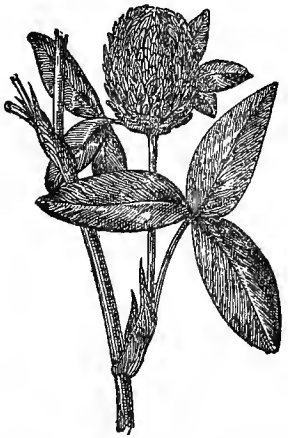


Fig. 551.—Perennial red clover (*Trifolium pratense perenne*).

thus accurately described in *Permanent and Temporary Pastures*, Sutton, sixth edition, p. 78:—

"*Trifolium pratense perenne* differs from broad clover (fig. 552) in having a somewhat taller, smoother, and, except in its very young state, a less hairy stem, and a stronger, less fibrous, and more penetrating root. It carries its flowers some way above the foliage, surpasses broad clover in succulence and weight of crop, and stands frosts much better.

"The root of perennial red clover reaches down into the subsoil, enabling it to obtain moisture and nourishment in the hottest weather, when red clover gives up from drought. This penetrating habit also affords a means of sustenance to the plant on land which is too poor to grow broad clover, and frequently makes it desirable to increase the proportion of this seed for pastures on thin uplands.

"Perennial red clover has two characteristics which greatly augment its value: flowering does not begin until at least ten days later than broad clover, and the more robust and solid stems remain succulent and eatable by stock long after broad clover has become pithy and withered. Perennial red clover fills up the gap between the first and second cuttings of broad clover, and comes into use at a time when no other green food is available for the horses of the farm, but it rarely gives a second crop of any consequence.

"Cow-grass produces comparatively little seed from its single crop; whereas red clover yields a good crop of seed from the second cutting, after the first has been taken as fodder. Consequently seed of the perennial variety is necessarily high in price."

Sinclair says, in his *Hortus Gramineus Woburnensis:* "In the fertile grazing lands between Wainfleet and Skegness in Lincolnshire, this true perennial red clover (*Trifolium pratense perenne*) is abundant. . . . Last summer, when examining the rich grazing lands in Lincolnshire, I found this plant to be more prevalent than any other species of clover. . . . The natural appearance of this plant in these celebrated pastures is such as to recommend it strongly for cultivation. It being strictly perennial, and the root only slightly creeping, it may be used for the alternate husbandry, for which the *Trifolium medium* is inadmissible on account of its creeping roots,

Fig. 552.—Red or broad clover (*Trifolium pratense*).

constituting what, in arable lands, is termed *twitch*. . . . The nutritive powers of this species are superior to those of the *Trifolium medium*. . . . It thrives better when combined with other grasses than when cultivated by itself; but this, indeed, is also the case with all the

valuable grasses. . . . The slightly creeping root remains permanent in the experimental garden, while the roots of the common broad-leaved clover have almost disappeared in the third season from sowing. For permanent pasture, therefore, this variety (*Trifolium pratense perenne*) is the only proper one to cultivate."

Meadow Trefoil.—*Trifolium medium*—meadow trefoil—is often confounded with perennial red clover, otherwise so worthless a weed would never have been recommended as a valuable constituent for our permanent pastures on light soils, where it never fails, by its obtrusive character, to destroy the more valuable pasture-plants around it. Sinclair owns that "the *Trifolium medium* is inadmissible in alternate husbandry, on account of its creeping roots, constituting what, in arable lands, is termed *twitch*"; and the twitch is most abundant, and therefore most troublesome, in light soils, not only in arable fields, but in pasture, where it usurps the place of better plants.

Creeping Trefoil.—*Trifolium repens*—creeping trefoil, Dutch white, or sheep's

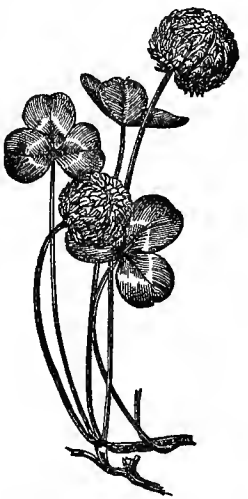


Fig. 553.—Perennial white clover (*Trifolium repens perenne*).

clover (fig. 553)—is indispensable for low-lying pastures, and is, indeed, better adapted to pastures than to meadows. Curtis affirms that a single seedling covered more than a square yard of ground in one summer.

White Clover.—White clover is sometimes called shamrock, but it is not the true Irish shamrock. In the eastern counties it is called white suckling, which fact causes it to be confounded

Fig. 554.—Alsike clover (*Trifolium hybridum*).

with *Trifolium minus*—yellow suckling, which latter plant in Norfolk and Suffolk, singularly enough, is invariably called red suckling.

Alsike Clover.—*Trifolium hybridum*—hybrid trefoil, Alsike clover (fig. 554)—is a species possessing the properties of the red and white clovers, and was considered by Linnæus a hybrid between them. It is a native of the south of Europe, but has been introduced into the agriculture of Germany and Sweden, where it is cultivated to considerable extent in the district of Alsike. Its average duration is three years, it resists cold well, it thrives in moist lands and under irrigation, but is susceptible to drought.

Trifolium incarnatum.—*Trifolium incarnatum*, a most beautiful dark crimson-flowered clover, makes good food for cattle, and grown with winter barley, or sown alone on wheat stubbles in August, it makes excellent fodder for sheep in the month of May. It is strictly an annual, and can never be sown without risk north of the Humber. There are now in cultivation four distinct varieties—*T. incarnatum*, *T. incarnatum tardum*, *T. incarnatum tardissimum Suttoni*, and *T. tardissimum album*.

By sowing all these varieties at the

same time in the autumn, the period during which Trifolium can be fed or cut the following summer will be extended to at least a month; whereas when the early Trifolium is sown alone, it has to be all consumed in about a week, to prevent its getting pithy and worthless.

Trifolium minus—yellow suckling—is often confounded with *Medicago lupulina*, yellow or hop trefoil. Suckling, however, is much harder, and more wiry in the stem, darker in the foliage, and has paler flowers than the *Medicago*. Although an annual or biennial, it is much more suited to permanent pastures than trefoil is, and is equally at home on dry soils and strong land.

Medicago lupulina (fig. 555).—Although not a *Trifolium*, no account of

Fig. 555.—Common yellow clover or trefoil (*Medicago lupulina*).

the agricultural clovers would be complete without reference to this plant, commonly known under the names of trefoil, black medic, or hop clover. This is the earliest of all the clovers to come to maturity in spring. On calcareous soils it is invaluable.

These are all the species of clover that seem to deserve special notice, out of 166 described by botanists.[1]

Impurities in Clover.—The most frequently occurring impurities in samples of clover seed are the seeds of dodder, plantain, sorrel, dock, cranesbill, wild carrot, self-heal, corn bluebottle, chickweed, chamomile, and scorpion grass.

[1] Don's *Gen. Sys. Garden. Bot.*, ii.—"Legumen."

VARIETIES OF GRASSES SOWN.

For one year's lea it has been usual for them to consist only of red clover, *Trifolium pratense;* white clover, *Trifolium repens;* rye-grass, *Lolium perenne;* Italian rye-grass, *Lolium Italicum;* and, on light soils, the yellow clover, *Medicago lupulina*. These, in common parlance, are called the *artificial grasses*, because they are sown every year like any other crop of the farm, and are of temporary existence.

But of late it has been found very desirable to include other strong-growing perennial varieties, such as cocksfoot and timothy, even where the mixture is to remain down but one season, and they are still more indispensable for 2, 3, 4, or 6 years' leas. The quantities sown vary but little over the country. The seeds are proportioned according as the grasses are to remain for one year or longer.

SEEDS FOR ROTATION GRASSES.

It is not advisable to attempt to prescribe definite mixtures of seeds for extensive areas of land in different parts of the country. Every county and district has peculiarities of climate and soil, which should be taken into consideration when deciding upon the exact varieties and proportions of the grasses and clovers sown. But the following mixtures will generally be found a useful standard to work by:—

For *One Year's Lea.*—Where clovers are to be sown alone, 16 lb. should be sown per acre, in the following proportions:—

	lb.		lb.
Trefoil . .	5	Red clover .	6½
White clover .	1½	Suckling . .	1
Alsike . .	2		

Cost about 12s. per acre.

Where rye-grass is the only grass used, 20 lb. in all should be sown, and the following will be found a desirable prescription:—

	lb.		lb.
Rye-grass .	8	White clover .	½
Red clover .	8	Suckling . .	½
Trefoil . .	3		

Cost about 12s. 6d. per acre.

But a far better prescription (20 lb. in all), and one costing no more, is the following:—

	lb.		lb.
Cocksfoot	½	Suckling	½
Rye-grass	4½	Alsike	1
Italian rye-grass	3	Trefoil	4
White clover	1	Timothy	1
Red clover	4½		

Two Years' Lea.—When a lea has to remain down for two seasons, a slightly heavier seeding is required, and 24 lb. in all should be sown. The following is an extremely useful prescription:—

	lb.		lb.
Cocksfoot	2	Red clover	2½
Rye-grass	6	Alsike	3
Italian rye-grass	4	Trefoil	2½
Timothy	3	Suckling	1

This will cost about 14s. 6d. per acre, but must not be depended upon for more than two years.

For 3 *or* 4 *Years' Lea* other valuable grasses, like foxtail, meadow fescue, and lucerne, may be included with advantage: 32 lb. should be sown per acre, made up as follows:—

	lb.		lb.
Foxtail	1	White clover	2
Cocksfoot	2	Cow-grass	3
Meadow fescue	1	Alsike	1
Rye-grass	12	Suckling	1
Italian rye-grass	4	Lucerne	1½
Timothy	2½	Trefoil	1

Cost about 20s. per acre.

For 5, 6, *or* 7 *Years' Lea*, from 36 lb. to 40 lb. of seed should be sown per acre, and may consist of the following:—

	lb.		lb.
Perennial rye-grass	12	Cocksfoot	2
Italian rye-grass	8	Timothy	2
Foxtail	1	Cow-grass	1½
Meadow fescue	2	White clover	1½
Hard fescue	3	Suckling	1
Smooth-stalked meadow-grass	2	Lucerne	½
		Trefoil	2½
		Alsike	1

The cost of this need not exceed that of the foregoing mixture.

The process of sowing these temporary mixtures is so identical with that practised in the sowing of permanent grasses, that the whole subject may be treated under one head.

GRASSES AND CLOVERS FOR PERMANENT PASTURE.

With the decline in the price of wheat in this country there has come a great extension in the area under permanent pasture, and there is every reason to believe that this area will continue to increase. Still, soil and climatic influences must determine in a great measure the extent of arable land that can with profit be converted into permanent pasture. Districts like the eastern and southern parts of England, being dry, are better adapted for corn than grass, and a glance at the returns for the various counties will show that the proportion of land under grass is smallest where the rainfall is lightest. In the western and northern districts, where the rainfall is heavy and strong lands abound, the summer is colder, and thus grass preponderates.

Permanent seeds like lea mixtures are generally sown in corn, and a wheat plant is perhaps best for this purpose, though oats and barley are much more commonly chosen.

Grasses for different Soils.—It is impossible to give exact advice as to the kinds and quantities of grasses and clovers required, in consequence of the extreme diversity of the soils of the country, but the following table will help greatly to determine which varieties are most suitable for any particular soil under consideration. An ample seeding per acre is 28 lb. of the larger grasses and 12 lb. of clovers, &c.; and nearly all prescriptions include the following varieties:—

Grasses.	Especially suitable for—
Agrostis stolonifera (fiorin)	Heavy and alluvial soils.
Alopecurus pratensis (meadow foxtail)	Rich deep soils.
Anthoxanthum odoratum (sweet vernal)	Medium and light soils.
Avena elatior (tall oat-grass)	All soils.
Avena flavescens (yellow oat-grass)	Dry and calcareous soils.
Cynosurus cristatus (crested dogstail)	Medium and light soils.
Dactylis glomerata (rough cocksfoot)	All soils.
Festuca duriuscula (hard fescue)	Medium, light, and thin soils.
Festuca elatior (tall fescue)	Deep heavy soils and clays.
Festuca ovina (sheep's fescue)	Calcareous and thin soils.

Grasses.	Especially suitable for—
Festuca pratensis (meadow fescue)	Medium and heavy soils.
Lolium perenne (perennial rye-grass)	All soils.
Phleum pratense (timothy grass)	Deep heavy soils, clays, and alluvial.
Poa nemoralis (wood meadow-grass)	Rich medium soils.
Poa pratensis (smooth meadow-grass)	Light thin soils.
Poa trivialis (rough meadow-grass)	Rich, heavy, and alluvial soils.

Standard Seed Mixtures.—The following prescriptions may be considered very safe standards:—

Good Loamy Soil.	lb.
Foxtail	2½
Sweet vernal	½
Cocksfoot	4
Meadow fescue	3½
Sheep's fescue	1½
Hard fescue	3
Red fescue	2
Perennial rye-grass	9
Smooth-stalked meadow-grass	½
Rough-stalked meadow-grass	1
Wood meadow-grass	½
Dogstail	½
Timothy	2½
Lucerne	1
White clover	2½
Cow-grass	2
Alsike	1½
Suckling	½
Yarrow	¼

Costing about 35s. per acre.

Gravelly Soil.	lb.
Fiorin	½
Golden oat-grass	½
Sweet vernal	½
Cocksfoot	2
Meadow fescue	2
Sheep's fescue	1½
Red fescue	3
Hard fescue	3½
Perennial rye-grass	9
Smooth-stalked meadow-grass	3½
Wood meadow-grass	1½
Dogstail	1½
Timothy	1
Lucerne	1
White clover	2
Cow-grass	2
Trefoil	1
Suckling	3
Yarrow	¼
Lotus corniculatus	¼

Costing about 32s. per acre.

Clay Soil.	lb.
Fiorin	2
Foxtail	4
Cocksfoot	4
Meadow fescue	3
Tall fescue	1
Hard fescue	1½
Perennial rye-grass	9
Rough-stalked meadow-grass	1½
Timothy	4
White clover	1
Cow-grass	2½
Alsike	3
Trefoil	1½

Costing about 36s. per acre.

Peaty Soil.	lb.
Foxtail	2
Agrostis	4
Cocksfoot	2½
Tall fescue	1
Meadow fescue	4½
Water meadow-grass	1
Smooth-stalked meadow-grass	2½
Rough-stalked meadow-grass	1½
Timothy	3½
Perennial rye-grass	9
Trefoil	3½
Alsike	1½
White clover	1½
Cow-grass	2

Costing about 34s. per acre.

Mr De Laune's Mixtures.

Reference has been made to the objections raised by the late Mr Faunce de Laune to the inclusion of rye-grass in seed mixtures for permanent pastures (p. 237). Although, as indicated there, good reason has been shown why farmers should still put faith in rye-grass, it may nevertheless be of interest to produce here the particular mixtures of seeds recommended by Mr De Laune for the formation of permanent pastures on different soils. They are as follows:—

	Good or Medium Soils. lb. per acre.	Wet Soils. lb. per acre.	Chalky Soil. lb. per acre.
Foxtail	10	4	...
Cocksfoot	7	10	14
Catstail	3	3	3
Meadow fescue	6	3	2
Tall fescue	3	8	...
Crested dogstail	2	2	5
Rough meadow-grass	1½	2	...
Hard fescue	1	1	4
Sheep's fescue	1	...	4
Fiorin	1½	2	...
Yarrow	1	1	2
Golden oat-grase	...	...	1
Perennial red clover	1	1	1
Cow-graes	1	1	...
Alsike	1	1	1
Dutch clover	1	1	1
Total lb.	41	40	38

SOWING GRASS SEEDS.

It is important that the most careful attention should be given to the process of sowing grass seeds, for much depends on the manner in which the sowing is carried out.

Time of Sowing.—The best time for sowing depends much upon the weather, and no hard-and-fast period can be named. April may be properly regarded as a safe and favourable month in which to sow; but if the seed-bed is ready, and the land in working order by the beginning of March, there need be no scruple as to putting in the seed. On heavy soils grass seeds are frequently sown in August or September. Grass seeds are usually sown along with a cereal crop.

Sowing before is better than immediately after a shower, even supposing the land can be worked soon after rainfall. The seeds sown before rain gradually absorb moisture from the soil and dew until wet weather sets in, and then the plants spring up with great rapidity.

Depth for Grass Seeds.—Depth of sowing affects no plants so sensibly as the grasses. Some experiments were made at Glenbervie, Falkirk, to ascertain the depth at which the common grass and clover seeds should be set, to produce the greatest number of plants. The same weight of seed was sown of each kind, and as different seeds differ in bulk and weight, the numbers of each kind differed materially. A better plan would have been to have sown the same number of seeds of each kind whatever their weight, and the proportion which came up of the plants would have been more easily ascertained than by the method adopted. Each kind of seed was covered from ¼ of an inch to 3 inches of depth in the soil. They were sown on the 1st of July, and counted on the 1st of August, and the results are shown in the following table:—

KINDS OF SEED EXPERIMENTED ON.	No. of seeds sown altogether.	COVERED AT												No. of plants that came up.	Proportion of plants that came up.
		¼ in.	½ in.	¾ in.	1 in.	1¼ in.	1½ in.	1¾ in.	2 in.	2¼ in.	2½ in.	2¾ in.	3 in.		
Perennial rye-grass (*Lolium perenne*)	348	29	30	27	19	16	19	14	21	11	9	8	4	198	·57
Italian rye-grass (*Lolium Italicum*)	276	24	21	20	13	13	10	11	8	9	6	5	5	145	·51
Cocksfoot (*Dactylis glomerata*)	300	30	22	15	15	10	9	7	5	2	..	..	..	115	·38
Large fescue (*Festuca elatior*)	312	20	24	20	16	13	13	11	9	4	2	1	..	142	·42
Meadow fescue (*Festuca pratensis*)	324	28	28	16	12	10	6	9	4	2	?	..	..	117	·36
Varied-leaved fescue (*Festuca heterophylla*)	348	31	23	20	18	12	9	6	4	1	..	..	..	124	·35
Hard fescue (*Festuca duriuscula*)	300	30	23	10	15	10	8	5	3	1	..	..	..	114	·38
Meadow foxtail (*Alopecurus pratensis*)	192	17	17	16	15	12	7	6	3	1	..	..	..	94	·49
Timothy grass or meadow cats-tail (*Phleum pratense major*)	528	52	39	37	19	16	15	7	5	..	..	..	..	190	·36
Evergreen wood meadow-grass (*Poa nemoralis sempervirens*)	228	24	14	4	1	..	..	..	..	..	..	..	..	43	·18
Rib-grass (*Plantago lanceolata*)	252	22	25	19	17	14	11	10	8	6	2	..	..	134	·53
Red clover (*Trifolium pratense*)	192	17	16	14	11	11	8	4	4		.	..		85	·44
White clover (*Trifolium repens*)	144	13	11	6	4	3	1	..	..	..	..		.	38	·26
Yellow clover (*Medicago lupulina*)	96	12	10	8	6	4	2	..	..	..	..	..	..	42	·43
	3840	349	303	232	181	144	118	90	74	37	21	14	9	1581	·46

In only 3 cases did the number of plants exceed ½ the seed sown, those being perennial and Italian ryegrass and large fescue—the average of the whole being under ½—viz., .46. The clovers came up in small proportion, particularly the white, which is considered a hardy plant in this climate. Of the depths, the ¼-inch covering gave the largest return of plants, and 16 per cent more than ½ inch.

Mr John Speir, Newton Farm, Newton, Glasgow, states that, in a series of trials with grass and clover seeds sown at different depths up to 1½ inch, he obtained results which do not agree with these recorded at Glenbervie. Mr Speir remarks that his experience does not favour so shallow a covering as is likely to be got by first rolling, then sowing, then harrowing with a light-toothed or chain harrow, and finally rolling. He is thus opposed to rolling prior to sowing grass seeds.

In such soil as prevails on Mr Speir's farm, which is not difficult to reduce to a fine tilth, there will rarely be any necessity for rolling before sowing. Rolling is unquestionably beneficial when by the harrows a fine smooth surface cannot be prepared for the grass seeds. If chain or light-toothed grass-seed harrows will not provide a sufficiently deep covering for the seeds after rolling, then ranker-toothed harrows may be used. The object aimed at in using the roller before sowing is to secure for the small seeds a firm level bed, where their regular brairding will not be interfered with by clods and heights and hollows. Where this can be obtained without prior rolling, there is no need to occupy time with this operation.

Methods of Sowing.—Grass seeds are sown by hand and with machines. The hand-sowing is confined mainly to small farms, while on moderate and large farms the machine is almost universally used.

Hand-sowing.—Sowing grass seeds by hand is a simple process, although it requires dexterity to do it well.

Clover and rye-grass seeds are so different in form and weight, that they should never be sown at one cast. The sower has little control over the grass seed, the least breath of wind taking it wherever it may. His sole object is to cast the seeds equally over the surface, and, as they cannot be seen to alight on the ground, he must preserve the strictest regularity in his motions. Being small and heavy, the clovers, even in windy weather, may be cast with tolerable precision. It is pleasant work to sow grass seeds by the hand. The load is comparatively light, and the ground having been harrowed fine, and perhaps rolled smooth, the walking is easy.

Machine-sowing.—But now the grass-seed broadcast sowing-machine, fig. 419, has superseded the necessity of hand-sowing on most farms. This is a most perfect machine for sowing grass seeds, distributing them with the utmost precision, and to any amount, and so near the ground that the wind affects but little even the lightest grass seed. Its management is easy when the ground is ploughed in ordinary ridges. The horse starts from one head-ridge, and walks in the open furrow to the other, while the machine is sowing half the ridge on each side, the driver walking in the furrow behind the machine, using double reins. On reaching the other head-ridge, the gearing is put out of action till the horse, on being *hied*, enters the next open furrow from the head-ridge; and on the gearing being again put on, the half of a former ridge is sown, completing it with the half of a new one by the time the horse reaches the head-ridge he started from. Thus 2 half-ridges after 2 half-ridges are sown until the field is all covered.

The seed is supplied from the head-ridge, upon which the sacks containing it were set down when brought from the steading.

The head-ridges are sown by themselves. But the half of the ridge next the fence on each side of the field cannot be reached by the machine, and must be sown by hand.

When ridges are coupled together, the horse walks along the middle between the crown and open furrow, the furrow-brow being the guide for one end of the machine, and 2 ridges are thus sown at every bout. Where ridges are ploughed in breaks of 4 ridges in width, the furrow-brow is the guide in going and the crown in returning, while sowing 2 of the ridges; and the crown in going and the furrow-brow in returning, while sowing the other 2 ridges.

Speed of the Sowing-machine.—Were this machine to sow without interruption for 10 hours, at the rate of 2½ miles per hour, it would sow about 45 acres of ground; but the turnings at the landings, and the time spent in filling the seed-box with seed, cause a large deduction from that extent.

Grass-seed Harrows.—After the grass seeds are sown, the ground is harrowed to cover them in. For this purpose lighter harrows are better than the ordinary, which would bury clover seeds too deeply in the ground. These light harrows are arranged (with wings) to cover a large breadth at a time, so that the sowing of grass seeds is a speedy process. Fig. 556 is grass-seed harrows, with wings, covering a ridge of 15 feet wide at one stretch. The harrows have a set of iron swing-trees. Modern har-

rows well suited for covering grass seeds are shown in fig. 557.

Working wide Harrows. — Some dexterity is required to drive these wide grass-seed harrows. They should not be moved from one ridge to the adjoining, as part of the implement would then have to turn upon a pivot, which might

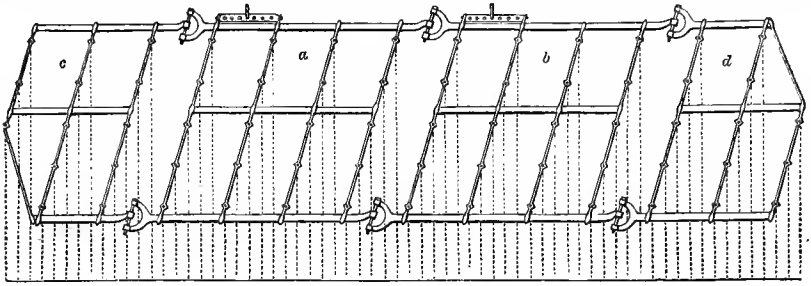


Fig. 556.—*Grass-seed iron harrows, with wings and swing-trees.*
a b Main leaves of the harrows. *c d* The 2 wings.

wrench off a wing. Besides, it is inconvenient to *hup* the horses with these harrows. To avoid the inconvenience is to *hie* the horses at the end of the landings, round an intermediate unharrowed ridge.

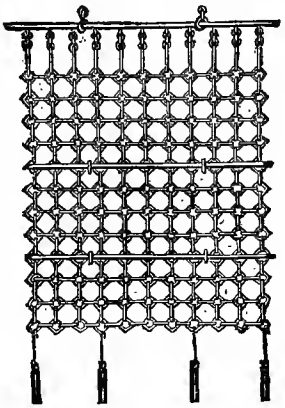


Fig. 557.—*Chain harrows.*

Harrow Carriage. — Fig. 558 is a convenient and safe form of carriage for conveying harrows. This is much better for the purpose than the ordinary cart. It consists of a frame of wood sparred in length to take on a pair of harrows coupled with their master-tree, and in breadth 3½ feet. The hind part of the frame rests on crutches supported upon the axle of 2 wheels, the upper part of the rim of which is below the top part of the frame; and the fore part rests upon a castor, which allows the carriage to be turned when desired. A horse, to draw the carriage, is yoked to 2 eyes of the fore-bar of the frame by the hooks of the plough-chains. The harrows are piled one above the other on the framing. Such a carriage may convey other articles to and from the fields.

Rolling for Grass Seeds.—The importance of thorough rolling in sowing grass seeds is not fully realised by the general body of farmers. It is of great moment that the small seeds should have an even firm bed, and this can best be secured by rolling, which also helps to retain the moisture in the soil, a matter of great importance in dry soils.

Rough land, if dry enough, should therefore be rolled before the grass seeds

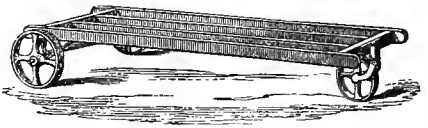


Fig. 558.—*Carriage for conveying harrows, &c.*

are sown. The rolling will reduce the clods before they become hard, and give a kindly bed to the small seeds. If the land is naturally dry, the roller is the more required to consolidate it after the winter's frosts. On light loams and turnip soils, the roller is often used with advantage both before and after sowing, the ground getting a turn of light harrows after receiving the seed.

When strong land is in a waxy state, between wet and dry, the rolling had better be deferred, but the sowing of the grass seeds may proceed, if the season, or state of the crop amongst which the grass seeds are to be sown, is already sufficiently advanced.

Crops accompanying Grass Seeds.—The cereal crops, amongst which grass seeds are sown, are winter wheat, spring wheat, oats, and barley. Winter wheat on bare-fallow clay sometimes grows so strong as to injure the young grass plants, but on lighter soils the grasses are always safely sown amongst it. There is little fear of spring wheat attaining to such growth as will injure the grasses amongst it. Oats are the usual vehicle by which to introduce grass seeds to the ground. Remaining but a short time on the ground, they permit young grass plants to grow considerably before winter, and become able to withstand the vicissitudes of that season. Barley, in some seasons, grows rank and thick, so as to endanger the existence of the grasses. Barley receives grass seeds in the same way as oats, but for some reason or other, probably because of the horizontal spread of the barley roots in the surface-soil, grasses do not thrive so well with barley as with oats.

Unless the winter wheat is too forward, the latter end of March will be the best time to put the grasses in. If the plant is strong, the common harrows will be required to obtain a hold of the ground; if weak, and the ground tender, the grass-seed harrows will be better.

Harrowing the Wheat-braird.—Winter wheat will be all the better for a harrowing in spring, even although some of the plants should be torn up by the tines, as it loosens the ground compressed by the rains, and admits the air to the roots of the plants. After such a harrowing, rolling will press the weak plants into fresh earth, and induce an immediate formation of new shoots by tillering; but should the plants have grown rank, the rolling should be dispensed with, in case of bruising the stems. The difference between bruising and bending the stems of wheat by rolling should be considered, so that rolling be done or left undone. A cereal crop, on a rolled surface, affords great facility for being reaped at harvest.

Many farmers sow grass seeds without harrowing them in, trusting that they may find their way into the soil amongst the clods, and be covered by their mouldering. But the safe and correct practice is to cover every kind of seed when sown.

Sowing with Spring Crops.—Although double-harrowing across prepares the land on which spring wheat is sown for the grass seeds, these are not sown at the same time as the wheat. The wheat may be sown during winter or early spring at any time when the state of the weather and soil permit. But when wheat is sown at the latest period, the grass seeds should not only be sown then, but also amongst the spring wheat previously sown; as also amongst the winter wheat, should there be any in the same field.

In fields in which wheat has been sown at different times, the grass seeds should be sown first on the latest sown wheat, then on the next latest, and last of all on the winter wheat. The reason for this is that it is desirable to finish the land most recently worked, in case the weather should change, and so prevent the finishing of the grass seeds over the whole field.

Frost Injuring Clover Seeds.—Frost injures clover seeds, and will even kill them when exposed to it, so they cannot safely be sown very early in spring, nor left unprotected without harrowing. But they run little risk of damage from frost in March when harrowed in, which is best done with the grass-seed harrows, the roller of course following.

If rolling the grass seeds amongst the corn cannot be done at the time of sowing on account of the raw state of the land, it should be done as soon as the state of the ground will permit, as it is of vast importance to have a firm bed for the grass seeds and a smooth surface in reaping the crop.

THE HAY CROP.

The importance of the hay crop to the agriculture of the United Kingdom is indicated by the fact that its annual yield reaches something like fifteen million tons. It occupies a larger area than all the cereal crops put together,—more than twice the area of the oat crop, which comes next to hay in regard to acreage. The treatment of the hay crop, therefore, deserves careful attention in any work dealing with the agriculture of the United Kingdom.

Varieties of Hay.—There are three main classes of hay: (1) "rotation hay," made from grasses and clovers sown in the preceding year; (2) hay made from sown grasses which have endured for several years; and (3) "meadow hay," or that made from natural meadows, the herbage of which consists of plants which have grown up at nature's own sweet will, or which had been sown many years back. The first is the class of hay most general where arable farming prevails, notably in Scotland and the north of England. The last abounds chiefly in the south of England and in certain districts in Ireland. The second variety is found here and there throughout the United Kingdom.

Tillage for Hay.—Nothing need be said here regarding tillage for hay. "Rotation-hay" usually follows a cereal crop; in some cases the seeds of grasses and clovers are sown without an accompanying crop, and then the tillage is in the main the same as for the cereal crops. For the reception of the seeds of grasses and clovers a fine tilth is of especial importance, and it is highly advantageous to have the seeds firmly packed in the soil by rolling.

MANURING THE HAY CROP.

The manuring of the hay crop is dealt with in the report on the Rothamsted Experiments in this volume, pp. 23-27. What is said there should be consulted at this stage; it would also be well to refer to the section on "The Fertility of Soil," vol. i. p. 317, as well as to the section on "Manures and Manuring," vol. i. pp. 446-520. It is of special importance to note the effects of the different manures on the herbage at Rothamsted—the encouragement which is given to deep-rooted plants by nitrate of soda, to shallow-rooted plants by ammonium-salts, and to leguminous plants by potash. Observe also the peculiar effects of lime upon the herbage at Rothamsted—effects which confirm the opinion that the value of liming the soil consists largely "in the neutralisation of acids, so that the organic matter can decay properly, and the liberation of reserves of potash in the soil" (vol. ii. p. 27).

Manuring Rotation Hay.—As a rule, rotation hay does not get any manures beyond what is applied to the preceding root crop. In a good many instances—and the practice is increasing—a portion of the manures is withheld from the root crop and spread on the "seeds" soon after the removal of the corn crop. Some farmers consider it a good plan to apply a part of the farm-yard dung in this way—that is, on the stubble where a hay crop is to be grown in the following season. About 8 or 10 tons is a good dressing for this purpose. Instead of dung, others give dressings of artificial manures, perhaps from 3 to 5 cwt. of basic slag or superphosphate, and on the lighter soils about 2 cwt. of kainit. For nitrogen, when it is needed, nitrate of soda in most cases does better than sulphate of ammonia. It is seldom that more than about 1½ cwt. of either is required for hay on well-managed land.

Manuring Meadow Hay.—The systems of manuring meadow hay vary greatly, according to the character of the soil, the situation, and the rainfall of the district. For land capable of giving a good response to liberal treatment, farm-yard dung, applied in the autumn at the rate of from 8 to 12 tons per acre, usually does well. Such a dressing as this may be repeated at intervals of three, four, or more years. It is not often profitable when applied every year.

The most general custom is to dress meadow-land with mixtures of artificial manures, known as "complete manures" —mixtures containing the three main essentials of plant-food which farmers have to supply — viz., nitrogen, phosphoric acid, and potash. These dressings are given as may be required, in some cases annually, and in others at varying intervals.

English Trials in Manuring Meadows.—Trials in the manuring of old grass-land for annual crops of hay, conducted over many years by the Armstrong College, Newcastle-on-Tyne, in Northumberland and Cumberland, gave interesting and useful results. Phosphatic manures were, as a rule, the most profitable, but on the lighter and peaty soils potash also did well. Nitrogenous manures, either in mixtures or alone, were seldom profitable, especially as they discouraged clover. Basic slag was in most cases the most effective and most economic phosphatic manure. Bone-meal also gave fairly good results. Neither dissolved bones nor superphosphate did so well, due, it is believed, to the soils being deficient in lime. It is advised that the basic slag and potash should be applied in early winter and be well harrowed in. Where the herbage is coarse a good plan is to run strong harrows over it before sowing the manure. For soils in poor condition up to 8 or 10 cwt. of slag and 2 cwt. of muriate of potash, or 6 cwt. of kainit per acre may be given.

About half this dressing may be applied every three or four years thereafter. Good results have been got from 10 tons of dung and 10 cwt. of basic slag per acre, with the repetition of half the dressing of both dung and slag every three or four years, — the combination of dung and slag being, on the whole, the most profitable dressing tried.

In poor land it is recommended that the aftermath be grazed instead of being cut and carried away.

Trials in Yorkshire.—Trials conducted in Yorkshire by the Agricultural Department of the Leeds University showed that 10 tons of dung given annually increased meadow hay by 16¾ cwt. per acre, but that a more profitable increase was got from 10 tons of dung the one year and a dressing in the next year of 2 cwt. superphosphate, 1½ cwt. of nitrate of soda, and 3 cwt. of kainit per acre. That mixture of artificial manures applied yearly without any dung gave results which "left a fair profit." In these Yorkshire meadows the aftermath is almost invariably grazed.

Reading Trials.—Extensive trials in the manuring of old grass-land for hay have been carried out by the University College of Agriculture at Reading. A dressing of 1 cwt. nitrate of soda, 5 cwt. basic slag, and 3 cwt. kainit per acre had a good influence on the hay crop for a period of five years. In a comparison of basic slag and superphosphate it was found that 5 cwt. of the former gave a better return than 3½ cwt. of the latter, though the percentage of phosphates was the same in the two dressings. The addition of 1 cwt. of nitrate of soda to the slag slightly improved the yield for the first two years. Even in clay soils kainit had a good effect. All over, the manurial dressings were beneficial, not only as regards the annual yield of hay but also in its quality, as well as in the quantity and quality of the aftermath.

Trials in Wales.—In trials on the manuring of meadows, carried out by the Agricultural Department of the University College of Wales, Aberystwyth, the best results were obtained from a "complete" dressing of artificial manures — 1 1/7 cwt. nitrate of soda, 2⅔ cwt. superphosphate, and 1½ cwt. kainit per acre. It was noticed that in all cases nitrate of soda had a tendency to produce rank herbage and to promote the growth of weeds and worthless grasses. Phosphates and potash, on the other hand, had the effect of improving the herbage, the potash plots in particular containing a much higher proportion of clover and finer grasses.

In North Wales experiments conducted by the Bangor College of Agriculture tended to show that the practice of dressing meadows with dung every year is not profitable. It was found that equal crops of better quality are grown at less expense by replacing the farmyard manure with artificials in alternate years. On land in fair condition, a dressing of farmyard manure every other year even

may be too frequent to give good financial results. For use alternately with farmyard manure the best combination of artificial manures has been basic slag and nitrate of soda, about 4 cwt. of the former and 1 cwt. of the latter per acre. Though kainit has occasionally given good results, as a rule it has not been needed. Excellent results have been obtained by the use of artificials alone applied every year, and for this purpose the above combination (4 cwt. basic slag and 1 cwt. nitrate of soda) has proved the best, with the addition in some cases of a little potash manure.

Yield of Hay. — The yield of hay varies greatly throughout the country. The general average of rotation hay for the United Kingdom is a little over 3 tons per acre, the yield in Ireland being over, and in Wales under, the average. The average yield from meadow hay is slightly under 3 tons per acre.

Aftermath.—The general practice is to graze the "aftermath" following meadow hay. It is only in exceptional cases that the meadow-land would long withstand the cutting and carrying away of more than one crop each season. In many cases the "aftermath" following "rotation hay" is cut at least once.

HAYMAKING.

There are few agricultural operations that are of greater importance to the British farmer than the converting of fresh grasses and clovers into hay by the drying influences of sun and wind.

Object of Haymaking.—Haymaking is the handmaid of stock-rearing. As stock-rearing increases or diminishes, so in all probability will haymaking as a branch of agriculture. Haymaking is the means by which the farmer endeavours to preserve for the winter feeding of his stock the class of food which they pick up for themselves on the fields in summer. The quality and feeding value of this preserved grass much depend upon the manner in which it has been transformed from the green to the dry condition. It is thus of the utmost importance that the process of haymaking should be conducted on the best method known and attainable. We say "attainable," because in our precarious climate the best-laid schemes of farmers are often upset by tantalising outbreaks of unfavourable weather.

Weather and Haymaking. — Haymaking is peculiarly subservient to climatic conditions. It goes without saying that hay cannot be made in wet weather. Even the proverbial injunction to "make hay while the sun shines" is not without limitation. By the too industrious "making" of hay, under clear scorching sunshine, the quality of the food may be considerably impaired. To expose the fresh grass to such drying influences as will preserve it with the least possible loss in its bulk and nutriment necessitates the exercise of the utmost skill and care.

It is therefore desirable that the various methods of haymaking pursued in different parts of the country should be discussed fully.

The chief principles of haymaking are alike applicable to all classes of hay. Several modifications desirable for particular varieties of grasses, and for certain localities, will be noticed presently.

The process of haymaking may, for the purposes of description and study, be conveniently divided into three sections—(1) cutting, (2) treatment between cutting and carrying, and (3) carrying and stacking.

CUTTING HAY.

Time for Cutting Hay. — An important preliminary is to decide when the crop is ready for cutting. For the moment the probability of unfavourable weather will be left out of consideration, and the weather will be assumed to be all the most ardent haymaker could desire. The precise time at which it is most desirable to cut down the crop will depend upon the object in view.

Hay for Seed.—If it is intended to obtain seed from the crop, then of course the plants must be left until the seeds have matured. This is easily determined. A few heads may be rubbed lightly in the hand, and the seeds and the heads examined. A common plan is for the farmer to sweep his hat smartly along the heads of the plants and note the seeds it catches.

Hay for Feeding.—But if the object is to raise good hay for feeding, and not to procure seed, then the cutting should take place at an earlier stage. It is well established, though the fact has not in all cases its due consideration in practice, that the production of seed and the securing of the maximum feeding value in the hay are incompatible. This is not due to the mere loss of the seed in the food, but rather to the fact that the seed is matured at the expense of the nutrient juices of the plants. It is the soluble ingredients of the hay—those soluble in water—which are chiefly valuable for feeding. Nearly all grasses and clovers contain the greatest quantity of these soluble ingredients when they are in full flower, and before the seed has been formed. The formation of the seed and/ the general ripening of the plants have a strong tendency to increase the proportion of woody fibre, and thus lessen the nutritive properties of the hay.

Best Stage for Cutting.—The stage, therefore, at which hay (from which seed is not to be taken) should be cut is when the plants are in full bloom, or at latest within a few days after the bloom or flower has disappeared. Many farmers delay cutting in the belief that any little loss by the maturing of certain of the plants will be more than made up by the increase which they imagine they obtain by growth of the under or bottom grass. This, however, is often fallacious.

Aftermath. — Moreover, the subsequent cutting or aftermath should be kept in view. The longer the first crop is left on the ground the poorer, as a rule, will be the after-growth. If the plants are left uncut until their stems become withered at the bottom, the plants may be so much impaired as to seriously lessen after-growth.

To ensure the greatest possible quantity of feeding matter in the course of the year—and this in the great majority of cases will be the object of the farmer—the best plan is to cut the first crop early rather than late. All things considered, it will be admitted that it is far more common for farmers to lose by delaying cutting too long than by cutting too early.

Premature Cutting.—Yet it is well to bear in mind the fact that the cry for early cutting may be carried too far. The agricultural chemist has shown clearly that the nutritive ingredients of grasses are not fully elaborated until the plants have reached the flowering stage,—in a few cases not indeed until the seed has been nearly ripened. Water is the principal constituent of young grasses, and it is not until they have reached the full stature of the flowering stage that the feeding properties are fully developed.

Thus the farmer should wait for the bloom before putting the mower into the hay-field. But when the flower appears he should have everything in readiness, and begin operations as soon as the weather justifies him in doing so.

Study the Weather.—In the foregoing remarks upon the time to begin cutting, it was assumed that the weather was favourable. Unfortunately, however, inclement weather has often to be contended with by the haymaking farmers of this country.

In the hay harvest the farmer must study the weather indications with unceasing care. In this he would do well to procure the aid of an efficient barometer, which can now be purchased for a very small sum.

Notwithstanding all that has been said as to the advantages of cutting the crop before the seed is formed, it will, as a rule, in the case of wet unsettled weather, be safer to delay the mower for a few days, until more settled weather sets in, than to cut down the hay and get it spoiled in the swathe by drenching rains. In contingencies of this kind, which are of frequent occurrence, the prudent farmer will choose the least of the evils which afflict him. There is no operation on the farm which demands more constant and careful attention or better judgment than haymaking. At best, in unfavourable seasons, it will often be a matter of compromise, involving not a little of the experimental element. Yet there are certain known conditions and influences which the haymaking farmer should bear in mind. The object here is to set forth these, leaving the farmer to apply them to his own individual circumstances.

Hay Injured by Wet.—One con-

sideration which the farmer should bear in mind is that rain is much more injurious to cut than to uncut hay. No nutriment is washed out of the stalk or blade of a grass while it remains in life, no matter how heavy the rainfall may be. When the plant is dead, however, every shower of rain to which it is exposed is liable to dissolve and wash away a certain portion of its most valuable feeding ingredients.

The warmer the weather the greater the loss from the wasting of hay by rain —this for the reason that warm water is, as a rule, a more powerful solvent than cold water.

Hot and Cold Rain.—The difference in the influence of hot and cold rain upon half-made hay is very noticeable in September, when a second cutting of grass is made into hay. At that season it is observed that the half-made hay will bear with impunity double the quantity of rain it would stand in June or July.

When wet weather sets in at the beginning of the hay harvest, it is not wise to go on mowing, in the expectation that the hay will be easily made safe when dry weather returns. Before the return of dry weather the cut grass may be seriously damaged by the drenching rains to which it is subjected.

It is better policy to delay cutting until the weather has become favourable. If there are indications of more rain at hand, the mowing should be prosecuted slowly, and then, when there is reason to believe that a spell of dry weather has set in, the order to all hands should be "full speed ahead."

Cutting Rotation Hay.—The two first varieties of hay mentioned above, those made from sown grasses and clovers, are roughly classed as rotation hay, as distinguished from hay made from natural meadows that lie permanently in grass. First years' hay, that grown from seeds sown in the previous season, as a rule consists chiefly of perennial or Italian rye-grass and clovers, or it may be all three. Perennial rye-grass and clovers are most largely used. If the weather is favourable the mowing of this hay should be begun when the rye-grass has been in flower for a day or two. If the breadth of hay to cut is great in comparison with the available force of labour, begin early, so that the main bulk of the crop may be cut down at the right time. In case of wet weather, delay a little as advised above.

Cutting Early and Late Grasses.—In hay from subsequent years' growth (as in meadow-hay), several of what are known as natural or permanent grasses are included in varying proportions. Of these permanent grasses cocksfoot and foxtail are among the earliest, and when these are plentiful the crop should be cut as soon as they go out of bloom. In a piece of meadow-land having a variety of grasses it is bad policy to lose the substance of the earlier grasses in waiting for the flowering of the later plants, more particularly if it should happen that the early varieties predominate. Here again it is erring on the side of safety to begin cutting early.

Ill-suited Mixtures.—Early and late grasses, so advantageous for grazing purposes, are not well suited for companionship in the hay crop. A certain amount of variation in this respect is practically unavoidable. It would be well, however, to guard against the association of extremes. For instance, it is imprudent to sow timothy and cocksfoot together for a hay crop. When the latter is ready for cutting, the timothy is not nearly at its best; while, if cutting were delayed till the timothy attained its greatest value, the cocksfoot would be deteriorated by over-ripeness. When timothy is sown for hay, which is extensively done, it is best sown by itself, as none of the other plants principally grown for hay ripen at the same time as it.

Clover, Sainfoin, and Lucerne.—Many experienced farmers consider it desirable to cut clover and sainfoin as soon as the first traces of the flower appear. Lucerne is often cut even earlier. In dry hot seasons its growth seems to cease before the flowering stage is reached, and in that case it is the practice with many to cut it down at once.

Preparing to Cut.

The prudent farmer will have the mowing-machines looked out and put into the pink of condition before the day arrives for the commencement of cutting. Any necessary repairs will have been effected at the end of the previous

season. No judicious farmer would think of laying up a machine or implement of any kind for the idle season until the needed repairs have been attended to. It is bad practice indeed to delay such matters until the time arrives for the active employment of the machine or implement.

These general remarks apply with special force to preliminary arrangements for hay-cutting. See that all preliminaries are attended to beforehand, so that when the work of cutting begins there may be no avoidable delay.

Methods of Cutting.

Mowing-machine.—To ensure satisfactory work, the mowing-machine must be in good order. Have the knives well sharpened, and see that they work smoothly and close to the face of the fingers.

It is advisable to use a good set of knives for cutting the hay crop, more particularly if the crop is heavy or contains a large quantity of soft grass in the bottom. Half-worn knives, although good enough for cutting oats or wheat, often make very unsatisfactory work in soft grass. Whenever cutting has begun, see that the cutter-bar is as near level as possible. In many cases the outside end is by far the closest—in fact, so close that the knives are often considerably damaged—while the inside end is so high that far too much of the crop is left on the ground.

Close Cutting.—Moderately close cutting is no doubt advisable on account of the greater weight of produce obtained than by higher cutting. Very close shaving, however, is doubtful policy. Indeed most good farmers regard it as decidedly undesirable. It incurs greater risk of delays and breakages in cutting. Then it is also observed that when the plants are cut excessively close to the ground, they are, as a rule (rye-grass and clover especially), unusually long in springing up again. In very hot dry weather the roots may be injured by undue exposure to the sun.

Sharp Knives.—Keep the knives as sharp as possible, as low-cutting and easy-drawn mowers cannot be had without sharp knives. Where two or more mowers are kept going, it is advisable to keep one man sharpening knives, as then they are always in good repair, and cutting goes on more smoothly and rapidly than when the driver has to look after not only his horses but his mower and knives as well.

The most common method of sharpening the knives of reapers is with a fine file supplied for the purpose. Machines such as is shown in fig. 473, vol. ii., for sharpening are now in use.

Mower *v.* Scythe.—The mowing-machine is now almost universally employed in cutting hay. Except in the case of holdings too small to employ horse power, the advantages which the mowing-machine possesses over the scythe are so decided and great that the time-honoured scythe has been relegated to quite a secondary position.

Types of Mowers.—In the section on the harvesting of the grain crops, the introduction of the mowing and reaping machine has been referred to fully. Here it will suffice to say that this most useful appliance has reached a very high state of efficiency, and that the improvement in the working of the machines has been accompanied by the further advantage of a reduction in price. A very large number of firms are now extensively employed in manufacturing mowing (and reaping) machines, and farmers have the privilege

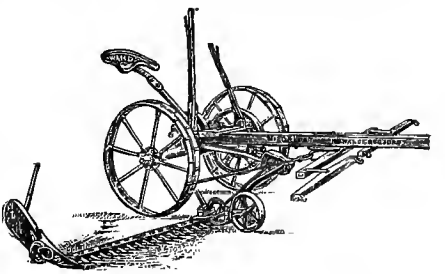


Fig. 559.—*Howard's mower.*

of selecting from a very ample collection of different "makes" and patterns, nearly all efficient, durable, and cheap, some of course better suited than others for certain localities and other conditions.

Excellent mowers are represented in figs. 559 and 560, made respectively by Howard, Bedford, and Harrison, M'Gregor, & Co., Leigh, Lancashire. The combined reaper and mower is a popular and most useful machine. Some

of the best forms of these are mentioned and illustrated in the section on the harvesting of grain. Fig. 561 represents a well-known machine made by Jack & Sons, Maybole, Ayrshire.

All-round or Side Cutting.—The greatest speed is of course, as a rule, attained by working the machine in a continuous course all round the field. This, however, is not always practicable or advantageous.

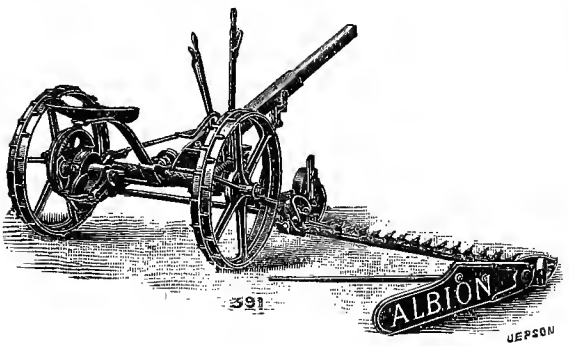


Fig. 560.—*The "Albion" mower.*

If the crop is moderate, and mostly standing, it may be cut round about where the field is no larger than can be cut in one day. Should the field be large, however, it will be advisable, even in a moderately standing crop, to cut two ways only, after having thoroughly opened up the field by taking four or five swathes round the outside. The field may then be cut into breaks about 50 or 60 yards wide, and the horses driven through the crop where a beginning is desired to be made. The crop, flattened by the horses' feet and the wheels of the machine, should be cut on the return journey, as the fingers then get easily in below it, and cut it clean. Unless the crop is very light, a narrow track should, before coming back, be cleared by the rake for the inside wheel, otherwise it is liable to get blocked up by loose hay. The trouble is very little, and much neater work can be done. The cutting may then be proceeded with till the breadth cut is equal to what remains between the first beginning and the side of the field, after which the mower should go round the remaining part.

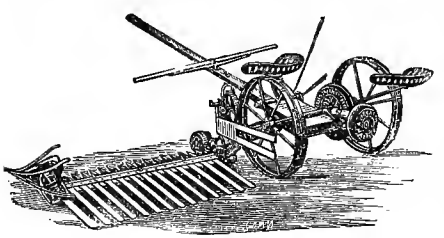


Fig. 561.—*Jack's reaper and mower.*

By cutting in this manner little unnecessary time is lost at the turnings. Many fields, if inclined to be laid, or if heeled over by the wind, can be easily enough cut in this way, while they would be anything but pleasant to cut round about. Moreover, by the cutting being done from one side or end of a field right forward, the crop can be much readier coiled and ricked afterwards, more particularly if the work is interrupted by bad weather.

Laid Patches.—Where for any reason it is desired to cut a field round about, and patches here and there are lying in the wrong direction, it is the custom in some districts to turn such back by hauling a heavy plank broadside over the crop in the opposite direction to that in which the mower is moving, and a swathe or so in advance of it. A horse is yoked by a pair of plough-chains to the centre of the plank, a boy then gets on the horse's back and drives it where required.

Cutting Laid Crops.—If the crop is very heavy and laid, it, as a rule, can be cut only in one direction. In this case a beginning is generally made at that side of the field which admits of the mowing-machine going almost right against the direction in which the crop is laid.

Direction to Cut.—In choosing the direction in which to cut, it is always advisable to let the crop lie, if anything, against the divider instead of falling towards the horses' feet, as by doing so the face of the standing crop remains more

erect and clean than where the opposite course is followed.

Clearing Swathe Ends.—Where the crop is moderately heavy, it is a great convenience to the person in charge of the mower to have a boy or girl along with each machine, or one for two machines, who, with a rake, can clear a small space at the entry to each swathe, and draw back the cut hay after the first swathe and before the second; and when the finishes are not parallel, rake the cut crop out of the way, so as to allow a free passage out and in.

Head-ridges.—If the head-ridges are much laid or twisted, it may be impossible to cut them satisfactorily by the mowing-machine. In this case the scythe will have to be resorted to.

With the exceptions here mentioned, no other hand-labour need be used during the cutting process.

One-way Cutting.—If mowing is done one way only, the horses should always travel back in the clear spaces between the swathes, and the wheels of the mower should straddle the swathe of cut-grass. By so doing the grass lies much more open, and dries quicker and more regularly than where it is carelessly trampled on and pressed close to the ground. Another method is to form return roads at intervals by putting two swathes together.

Loosening Lumps.—The boys or girls who are keeping the ends of the swathes clear, or the man who sharpens the knives, should also come behind, and regularly throw out any unusually thick pieces of grass which have been pulled together by the bar of the mower, raked up by the boys, or from any cause whatever are gathered into a thicker part than usual.

Difficulties with Heavy Crops.—With very heavy crops, it often happens that the shedder of the machine is unable to turn back the cut grass. In that case boys or women should go along and turn it back with a rake handle. In a heavy crop which is tangled the growing plants are often pulled over by the shedder-board. In that case, unless the side of the standing crop is straightened up, the wheel of the inside shoe runs on the top of it, and the result is very indifferent work.

"MAKING" THE HAY.

The operations between the cutting and the carting or stacking of the hay may be conveniently described under the above heading. Indeed these operations may be said to constitute the "making" process.

Variations in Practice.—In this, which is really the chief part of the work of the hay harvest, practice varies greatly throughout the country. To a large extent, no doubt, these variations have no other grounds for their existence than the peculiar tastes and notions of the farmers themselves, who, it may be frankly confessed, own a full share of the contrarieties and perversities of human nature.

Grounds for Variations.—In most cases, however, the differences in the methods of haymaking are accounted for by variations in the soil, climate, system of farming, and the purposes for which the hay is intended. In particular, the making process must be varied with wet and dry seasons, heavy and light crops, and with the particular class of hay.

There is thus good reason for variety in the practice of haymaking; and while notes are appended descriptive of methods known to be pursued with success on widely separated parts of the country, and in different conditions of soil, climate, and system of farming, it is deemed right to say that it is not presumed that these are positively the best methods for all circumstances.

In haymaking, as in most farm practices, each individual farmer must think for himself. The prudent farmer is eager to know the methods which are pursued with success by others. Having acquainted himself with these, he must carefully consider their adaptability to his own peculiar circumstances. He will not hesitate to adopt such features of these methods as seem to improve upon his practice hitherto, yet he rightly deems it wise to introduce radical changes in a tentative way.

Haymaking controlled by Weather.—Haymaking, beyond almost every other farm operation, is incapable of being conducted with success upon any definite or hard-and-fast system. It is so thoroughly within the control of the "clerk of the

weather," and that important "functionary" is so fickle that every season, nay, even every week, may demand treatment peculiar to itself. The farmer must watch closely these uncertain and shifty conditions, and be prepared at any moment to vary his practice to suit them.

This very fact renders it all the more important that the farmer should acquaint himself as fully as possible with the various methods of haymaking pursued with success throughout the country, so that he may have the greater resource in battling with untoward circumstances as they arise.

English Methods.

In England, speaking generally, the prevailing methods of haymaking are somewhat different from those most largely pursued in Scotland and Ireland. As a body, Scottish and Irish farmers are not so highly accomplished in the art of haymaking as are their English brethren. Less experience and less encouragement are mainly accountable for this. There is only a very small extent of Scotland really well suited for hay-culture, while in many parts of England the hay crop plays quite a leading part in the economy of the farm.

We have many a time observed and contemplated with delight the care, intelligence, and methodical precision exhibited on well-conducted English farms in the harvesting of hay. The practice would seem to be reduced almost to the nicety of a fine art, and it is conducted with the enterprise and forethought happily characteristic of British agriculture.

Meadow Hay.—The making of natural or meadow hay—hay grown from permanent grasses—is, as a rule, slightly different from the making of rotation or clover hay. The former abounds largely in England and Ireland.

Haymaking Machines.—Tedding, swathe-turning, and other improved hay-

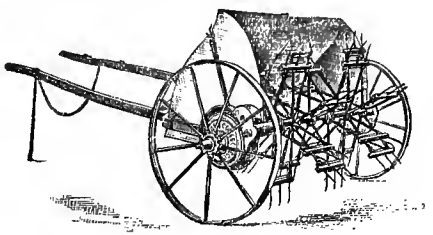


Fig. 562.—*Howard's haymaker.*

making machines are now largely used in all parts of the country. Types of these useful machines are represented in fig. 562, a double-action tedder or hay-

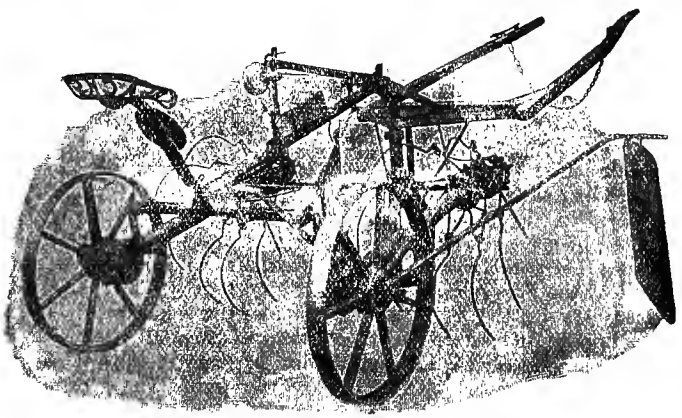


Fig. 563.—*Swathe-turner.*

maker, made by Howard, Bedford, and fig. 563, a modern swathe-turner, made by Blackstone, Stamford.

Swathe-Turning and Tedding.—Opinions differ somewhat as to the tedding or turning of hay. In favourable weather and with a good crop cut by the mower, most farmers set the tedder to work to scatter the swathes as soon as a few acres have been cut

down. Others think it better to leave the swathes to wither for a day or two before being disturbed. Obviously grass which lies in a thick swathe gets withered and dried on the upper side, while the portions on the lower side remain fresh and damp. If the weather should be favourable it is therefore inadvisable to delay stirring the swathe.

On many farms the crop is immediately turned a second time, and by this the "making" process is greatly expedited in dry weather.

Forward and Backward Tedding.—Tedders are made with both a forward and a backward action. By the first the grass is carried forward below the machine right over the top, and then scattered behind. In the backward action, the tedder merely picks up the grass and gives it a less or more vigorous "kick" backwards. The former movement is of course much more violent than the latter, and many farmers are opposed to it in the belief that the hay is thereby injured, seeds dashed out, and the leaves and stems bruised and broken.

Experiments in Tedding.—An important point in working the haymaking machine is the speed at which it revolves. In a series of experiments made by Mr Howard of Bedford, it was found that the barrels with the lowest speed for the back action made the best work, the crop being left looser and more hollow; the higher-speeded machines, owing to the greater violence of the throw, left the crop flatter on the ground.

Speedy Haymaking.—With a light crop the back action will be quite sufficient for spreading the swathes. Indeed, in some cases, in favourable weather, crops of a ton or more per acre are cut the one day, the swathes drawn into "windrows" by the horse-rake next forenoon, shaken out by the haymaker in the back action in the afternoon, then raked together, and carted in capital condition towards evening.

Tedding with High Wind.—High wind may be troublesome in haymaking. During a strong wind it is desirable to arrange for working the haymaker, when used in the forward action, sidewise to the wind: this may often be done by working obliquely across the swathes. It is, however, desirable to avoid using the forward action when the wind is trouble some, inasmuch as the crop becomes very unevenly spread.

Tedders injuring Clover Hay.—Hay in which clover forms a considerable part is liable to injury by the use of certain haymaking machines. The leaves of the clover become so brittle that the violent motion of the machine breaks them in pieces, and thus causes loss in the crop. Easy back action may be employed in fresh clover hay with impunity, if it is done carefully and at a slow pace. Turning with the hand-rake or modern swathe-turner is safer for clover-hay. Indeed, the swathe-turner, such as Blackstone's shown in fig. 563, is a most efficient machine for making clover, rye-grass, or timothy hay.

Collecting Hay.—In collecting the hay after it has been scattered for drying, manual labour has to a large extent given place to horse-labour and mechanical appliances. The horse-rake, such as that in fig. 564 (Ransome, Sims, & Jefferies), is

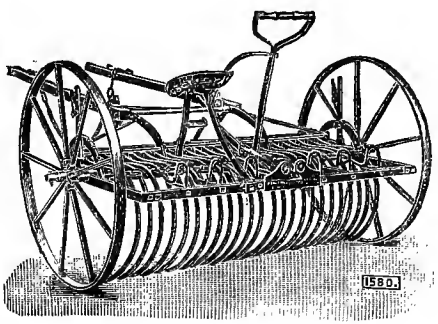


Fig. 564.—*Horse-rake.*

an excellent labour-saving machine, and is now universally employed. By it the partially withered grass is drawn into "windrows." The rake is started at the side of the field first cut, and emptied at intervals, regulated according to the carrying capacity of the rake and the weight of the crop. The rows of gathered hay thus formed are called "windrows." In these rows the hay lies loosely, and in this condition, with favourable weather, it dries speedily.

Where a modern swathe-turner is available, the rows may be turned once or twice during the day, in such a way that four swathes are put into one.

When this is done, gathering together by the horse-rake may be dispensed with prior to cocking.

Unless the weather is dry and quite settled, no more hay should be gathered into windrows than can be cocked in the same day. As will be readily understood, a fall of rain upon the windrows would cause more delay than a similar fall of rain upon hay in the swathe or thinly spread as by the tedder, for in this case the windrows would again have to be "spread out to dry." In dry, settled weather, more freedom may, of course, be exercised in these all-important operations.

"Cocking" Hay.—As soon as the hay is in a fit condition for putting into cocks, the horse-rake is run along the windrows, drawing the material into heaps, which by the hand-fork are speedily formed into cocks.

The practice in the cocking of hay varies greatly in different parts of the country, and is likewise modified to suit the weather at the time.

Large and Small "Cocks."—In the greater part of England the half-made hay is usually collected into very small cocks, often containing no more hay than a man could lift by the hand-fork at two or three turns, sometimes even less. In Scotland, Ireland, and the north of England the more general practice is first to put the hay into very small and then into larger heaps. In a damp climate, or in cases where the hay has to be carted a long distance to the homestead, big cocks may be desirable; but for moderately dry districts, or where expedition is the order of the day, there is much less advantage in the method. The practice of putting hay first into small and then into larger heaps is no doubt attended with waste, owing to so much hay being so long exposed. Still it has certain advantages, especially in the north, where, through the clashing of haymaking and turnip thinning, the former operation has often to be carried out by fits and starts. If large cocks are properly formed, a large amount of rain must fall before they will suffer much damage.

Differences in Methods.—Although it is convenient to treat of English, Scottish, and Irish customs separately, it should be stated that no very distinct line can be drawn between the practices of the three countries. In each country nearly all the known methods of haymaking are pursued to a lesser or greater extent. Certain methods are more prevalent in one district than in others, but the differences lie in degree more than in principle.

The English custom of taking the hay right from the first small cock or coil into large stacks or hay-sheds has the effect of saving time, and of inducing in the hay in the stack or hay-shed a certain amount of fermentation, which is regarded as rendering the hay more palatable to stock.

Scottish Methods.

In Scotland and the north of England first year's hay—that grown from grasses and clovers sown in the previous year—is the variety most general. Hay of this kind, especially when it contains a considerable proportion of clover, must be handled more tenderly in making than hay from permanent grasses, as the former is more liable to injury by breaking and bruising. This circumstance is in a large measure responsible for the distinctions between the methods of haymaking most prevalent in England and Scotland respectively.

Rotation Hay.—A light crop of rye-grass and clover, if cut before mid-day in clear dry weather, may be in condition to "coil" or "cock" by the afternoon of the day following. A heavy crop, however, even in good weather, will require a clear day between cutting and coiling; while an extra heavy crop, or one including a large amount of clover, will most likely require two clear days. If the weather be dull, damp, or wet, the process of coiling may be of necessity delayed an indefinite time.

Turning Clover Hay.—It has been explained that the turning of the swathes of hay grown from permanent grasses is usually performed by the haymaking or tedding machine. Rotation or clover hay, on the other hand, is generally turned by the swathe-turner or by a small hand-rake or the hand-fork, such as is shown in fig. 565 (Spear and Jackson). The reason for this difference in practice is, as already explained, that

the rotation or clover hay is more easily bruised and broken than the softer and tougher produce of the permanent grasses.

Process of Turning.—In the forenoon of the day on which it is considered that the grass should be ready to coil, the swathes should be turned over by rakes, so as to expose the under surface to the sun, and allow the wind to easily play through the whole mass. This it cannot do if allowed to lie one or more days in the condition in which it was left by the mower, as the longer it is left untouched the closer it lies to the ground, and although the upper surface may be hard and dry, the underlying stalks and leaves will be wet and damp.

Fig. 565. *Hand hay-fork.*

The turning-over process should, if at all practicable, be done early in the forenoon, so that as long time as possible may elapse between the turning and coiling, without allowing it to lie exposed to the dews of another evening, and the risk of rain on the day following.

The operation of turning by hand is best performed by the person walking in the cleared space left by the mower on the side of the swathe farthest from the turned-over part, and then by catching the folded-over part of the swathe with the teeth of the fork or hand-rake, and sharply pulling it towards him, the whole under surface is brought to the top. The work is more easily performed when the operator walks in the direction in which the mowing-machine was drawn. Several persons generally go together when turning-over is being done, the one following at a yard or two behind the other.

Care should be taken to turn the whole swathe upside-down, because if the work is slovenly done, the near side of the swathe will not be turned over at all, and, of course, when the hay is gathered together, those parts may in that case be quite damp, while the bulk of the hay may be in good condition.

Fit for Coiling.—If after mid-day the grass is withered and free of all positive damp or wet, even although it should have a raw feel, it will be in condition for coiling. Should the crop have lain on the ground for several days, and there be damp or wet parts in it which have not been exposed to the sun and air, it is a good plan to shake out the rows by hand or machine, or to rake it together an hour or two before coiling begins. By doing so the rake on being relieved turns the hay upside-down, so that any damp parts are exposed to the sun, and have a chance of getting dried before being covered up in the coil.

Again, it may be remarked, that so much depends on the crop, season, and weather, that it is impossible for any one to properly describe what are the requisite conditions of dryness suitable for coiling. It is not difficult to learn, but can be learned only by practice and experience.

Methods of Collecting the Hay.—It having been considered that the requisite dryness has been obtained, the crop may be gathered together by the horse-rake preparatory to coiling. The best rakes are the self-relieving ones, as the man can then devote all his attention to his horse and machine, and put off the rows more nearly straight and regular.

Coils or Cocks.—Coils or cocks are small conical heaps of half-dried hay, put together of such a size and shape as to admit of the hay continuing the drying process, and yet preserving it from serious deterioration by rainfall. According to the class of crop, the climate, and dryness of the hay at the time, coils range upwards in size from a yard in diameter and a yard in height.

Forming Coils.—Many used to contend that coils could best be made by the hands, unassisted by graips or forks, but this is rarely done nowadays. A forkful or an armful of hay is taken as left by the horse-rake, and roughly shaken and allowed to drop on itself as regularly as possible. A second forkful is then put on the first, being, however, a little more carefully shaken or spread, and kept within as little space as possible, so as

to leave the top narrow. A third and smaller quantity should now be taken and, more carefully than the previous two, shaken over the top. The coil will now present the appearance of a blunt-pointed cone widened at the base. The base is narrowed by pulling all the loose hay out and spreading it carefully over the top. The handfuls of hay, when pulled out, are comparatively straight, and when spread over the top of the coil assist very materially in throwing off wet.

Well-made Coils.—The protection of the hay from damage by rain in the coil much depends on the carefulness with which the bottoms or bases are pulled, and how the pullings are spread on the top. The operation is comparatively simple, yet many farm-hands do it badly; and while a properly-made coil is proof against any moderate rainfall, a badly-made one may be much damaged by a single heavy shower.

Badly-made Coils.—The great faults of badly-made coils are portions of the hay being put into the heap in a doubled-up condition, which holds the rain instead of throwing it off,—the one forkful or armful being put on the top of the other without being properly shaken out, which allows the rain to go down the division between the two, and admits of the top half being easily blown off; and neglect of pulling the bases causes the loose hay round the bottom to get easily wet, and when once wet it is difficult to dry—a well-pulled coil drying at the base in half the time required by a badly-pulled one. Neglect of pulling at the base also leaves the top of the coil unprotected, for the straight hay carefully spread over the top acts very much as thatch to an ordinary stack. It leads the rain from the top to the side, down which it readily flows, while without it the rain would run right down the centre of the coil.

Small Coils.—If the hay is not in thorough condition for coiling, and the weather looks as if rain were about to fall, the crop may be secured in smaller coils than usual, which will act as a partial protection against the rain, and yet be small enough to allow the wind to blow through them, and in part complete the drying.

Remaking Coils.—As soon as the weather has become bright again, the coils should be remade; and if the crop is now in moderately dry condition, two heaps may be put into one. Should the crop have been put together too green, the coils may be shaken out in the sun a few hours before being remade; but on no account should coils be shaken out to any great extent, unless the weather is such as to give a reasonable assurance of their being rebuilt before rain again falls.

Avoid Over-working.—At this stage it may be mentioned that rye-grasses and clovers are rarely improved by much shaking out and remaking. Hay from these plants, indeed, as formerly indicated, should always be secured with as little knocking about as possible.

Timothy Hay.—Timothy, like natural meadow hay, will stand a good deal of shaking. Timothy is the easiest secured of all the grasses, owing to the small proportion of leaves which it contains, and the length and strength of its seed-stalks. A heavy crop of timothy can often be cut the one forenoon and coiled the afternoon of the day following, whereas a similarly heavy crop of rye-grass and clover would require two or three days to get ready for coiling. The great preponderance of stalks which this crop contains over all others keeps it so open, that, in the coil, it dries much quicker and more efficiently than any other grass. Owing to the length of the stalk, timothy coils have generally to be made much larger than coils of other classes of hay. But its openness in texture, although an advantage in drying, is also a disadvantage in case of heavy rains. On account of its exceptional length and strength, timothy is probably the most difficult to coil properly of all the grasses, and in consequence it often is the worst coiled, the result being that heavy rains damage the crop very badly by running down through it.

Thunderstorms and Haymaking.—Coils, although a fair protection against moderate showers, are often little protection against heavy thunderstorms. Where thunderstorms are frequent and heavy, the system is therefore little resorted to for open crops such as clover.

Securing Wet Coils.—During a

heavy thunder-shower, or light continuous rain for one or more days, as occasionally happens, the rain often runs under the coils, and so wets them that only in exceptional cases could they ever be expected to dry if allowed to remain in their original position. After such rains the probability is that in a few days it will be found that, while the very top of the coil is dry enough, three or four inches farther down it is quite wet. If the weather is settled, and the centre of the coil is sufficiently dry to enable it to be put into the field-rick, or tramp coil or cock, the tops (which will likely be damp with the morning dew) may be taken off and laid to one side, while the body of the coil is taken away and secured in the rick, the bottoms also being left alongside the tops. These, if carefully spread out in the sun for an hour or two, very soon dry, and can ultimately be gathered up with the rakings.

If, however, the body of the coil is not dry enough to admit of being secured in the field-rick, the top should be taken off to well under the damp portion, and a new coil made, the tops and bottoms being loosely spread over the top. In this way the damp material very soon dries, unless the quantity of it has been all the greater, while at the same time the operation can be performed without exposing the crop to further damage from the elements.

Hours for Coiling.—As a rule, the dew prevents coiling early in the morning. In most cases coiling is done between eleven o'clock in the forenoon and evening, the bulk being done after midday.

Raking.—As soon as possible after the coiling is finished, the land should be raked clean between the rows of the coils before it gets any rain, if at all possible. These rakings are in some cases carefully spread over the tops of the nearest coils, and in others coiled by themselves. The rakings become soaked easily, and if once wet are difficult to dry, more particularly if they have been put on the top of the coil without being methodically shaken out. Great care should therefore be taken to see that only a few are put on each coil—if put there at all,—and that these are thoroughly shaken out.

Coiling in High Wind.—If a good breeze should be blowing during the operation of coiling, considerable annoyance is often caused by the tops being carried off. Under such circumstances the hay should be built well to the windy side of the coil, the operator always standing on that side, with his or her back to the wind. In this manner the coils can be built so that they are less liable to be blown over. After the field or plot is finished, the whole should be again gone over, and the damaged ones repaired, as when rain falls on them in this state they are liable to be seriously injured.

Time for Field-stacking.—The time hay should stand in the coil before being transferred to the stack is regulated solely by the dryness of the crop and the weather at the time. Where the crop is light, and has been well dried before being put into the coil, it occasionally may be stacked the day following, should circumstances and the weather permit. In fact, during dry and settled weather it often is not coiled at all, although in most parts of Scotland, unless under exceptional circumstances, the practice is not considered a good one.

The stage at which the crop will keep in the stack without loss of colour or excess of fermentation is one which must be seen to be learned, as it cannot be described in words. When, however, the hay is considered in condition to stack, no time should be lost in making it secure if the weather is at all favourable, for hay can never be considered anything like secure until it is in the stack or shed.

Temporary Stacks.—In districts where it is customary to sell hay and cart it direct from the field to the consumers' premises, field-stacks are usually made about one ton in weight, more as a matter of convenience for loading the carts than for any other reason. In other districts, however (and they are the most numerous), where the hay is consumed at home, the hay may not be stacked on the fields but in the stack-yard near the steading, or it may be put into hay-sheds. If put into the smaller size of field-stack, there is much less risk of damaging the hay by stacking it too soon. As a rule, hay can safely be put

into a 12-cwt. or 14-cwt. stack a day or two earlier than it would be judicious to put it into one weighing a ton. This alone is no mean consideration, for every additional hour the hay stands in the coils the greater will be its risk of damage.

Stack "Kilns" or "Bosses."—For the purpose of saving one or two days' exposure in the coil, it is customary in some districts to use triangles, "kilns," or "bossings" for the centres of the stacks. According to the district, these are usually from 6 to 10 feet high, and are made of thinnings of plantations or other suitable wood. Some farmers have a supply of such permanently bolted together at the top and nailed by spars at the sides, while others form them as required out of the ordinary supply of stackyard props. In the latter case they are usually tied at the top with a piece of stack-rope, which is made tight, no side-spars being used at all. Used in this way, stack-props serve a double purpose, and as single props they are more easily handled and stored away when not in use than are permanently made triangles. The labour of setting temporary triangles up is also very little, as a man can tie the three props together and set them up in a minute or two; and if there is likely to be little time for such while ricking is going on, they can often be made and erected in the morning before the dew is off the hay. Still the permanent "kilns" are in some respects more convenient.

Situation of Field-stacks.—In some localities it is the custom to build the stacks anywhere over the field, wherever hay can be got, while in others the usual method is to build a row of stacks across the rows of coils. If the rows of coils are short, say under 150 yards long, the stacks are built at the middle, and the crop brought in from both sides. If, however, the rows are longer, two or more rows of ricks may be required.

Hay-collector.—For the purpose of hauling the hay from each end of the row to the stack, several methods are in common use. An efficient method is by the hay-collector shown in fig. 566 (East

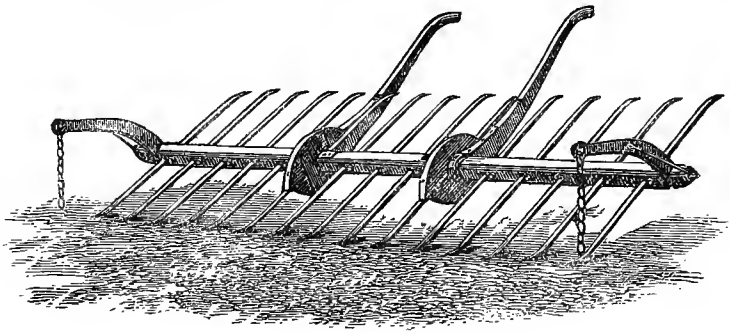


Fig. 566.—*Hay-collector.*

Yorkshire Cart and Waggon Co.) Appliances of this type are extensively used, and they do their work speedily and well.

Hay-sledge. — Another excellent method of collecting hay is by the hay-sledge shown in figs. 567, 568, and 569 (John Wallace & Sons). This sledge has two runners, which are usually straight or nearly so on the upper edge, and more or less curved on the under one. Across these are fixed four cross-bars, on which are nailed thin boards running the whole length of the sledge, which may either be fitted closely together or have spaces between each strip. The sledges may in size be from 7 feet to 9 feet wide, and say from 8 to 11 feet long. They are inconvenient if made wider than can easily pass through an ordinary field-gate. For the smaller sizes one horse will be sufficient to draw all that can conveniently be put on, while for the larger sizes two horses will be required.

In working, the sledge goes to the end of the row farthest from where the rick

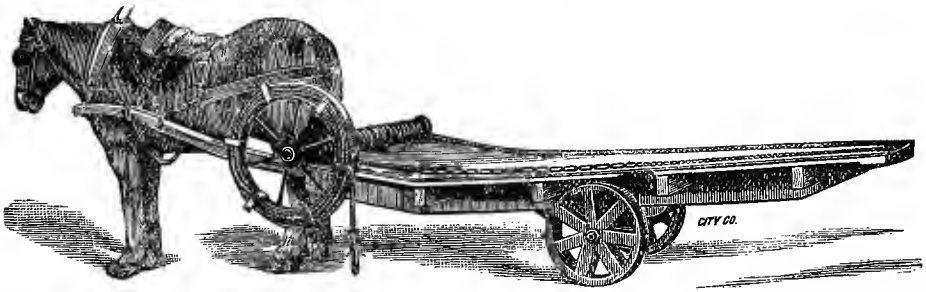


Fig. 567.—*Wallace's hay-sledge, empty.*

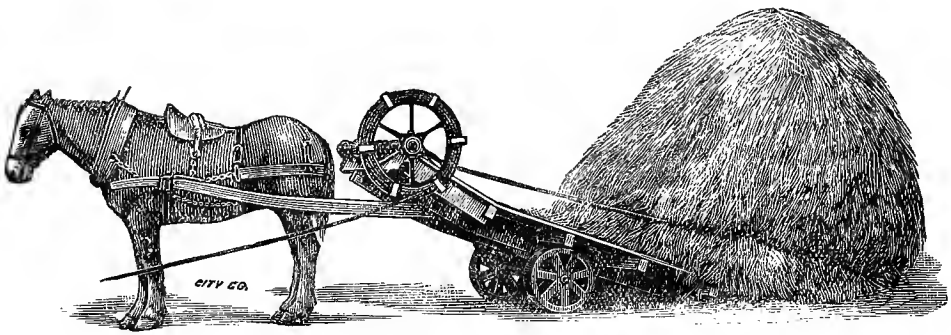


Fig. 568.—*Wallace's hay-sledge, in the act of loading.*

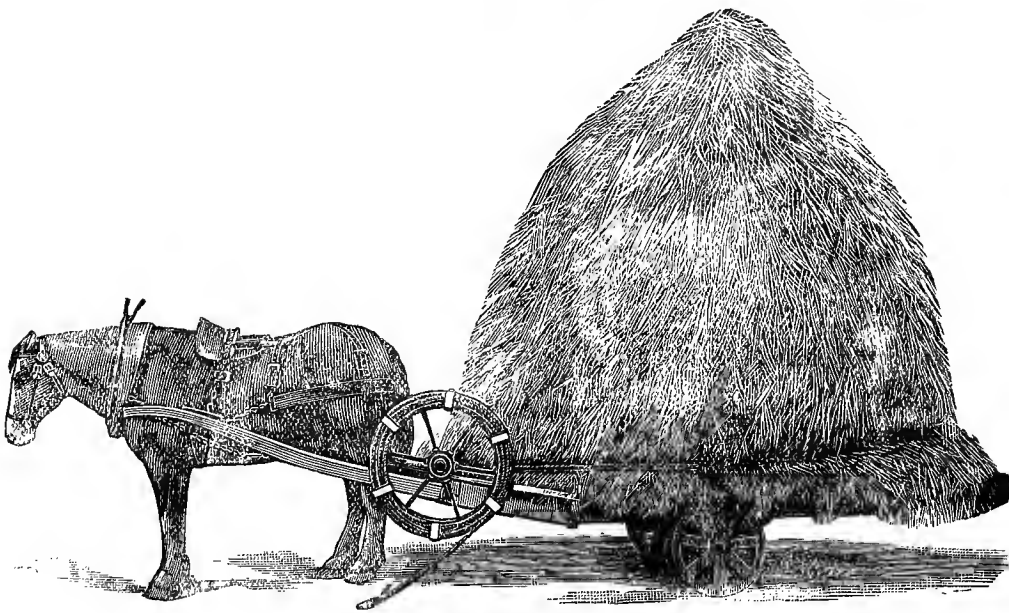


Fig. 569.—*Wallace's hay-sledge, with load.*

is to be, the coils being loaded on it as it moves nearer the rick. If the crop is light and the rows short, the whole row between the end and the rick will be cleared by one sledgeful. If longer and heavier, two loads may be required.

Loading the Sledge.—One person, usually a boy, will be required to lead the horse in the sledge, while one, two, or more boys, women, or men lift on the coils with light steel graips or forks, the former being preferable, as by the graip or spade handle the workman prevents the load from turning round in his hand, an accident which is frequently happening with the ordinary fork. Two persons, particularly women or boys, work best together, as they have then quite sufficient strength to lift between them a full coil each time. In this way fewer rakings are left, the hay is not unnecessarily tossed about, and is in consequence easier forked at the rick, while more can be put on the sledge than if each coil has been lifted at two or three times.

Unloading the Sledge.—On arriving at the rick two or more persons put their forks into the front part of the load, against which they throw their whole weight, when the lad moves forward the horse, thus pulling the sledge out from under the load. If the sun is bright and the hay dry, the load of hay is shoved off with little exertion. In fact, in going up even a slight incline the load may sometimes come off of its own accord; but if the sledge has been wetted by rain or dew, or by dampness from the bottoms of the coils, it is sometimes difficult to get the hay removed.

Other Methods of Hauling. — Besides the methods of bringing in the hay here described, there are several other ways in which the same operation is performed. The most primitive is to carry it in by forks, or as occasionally has to be done on soft meadows, by thrusting two poles under each coil and then carrying it off by two persons, after the manner of a double-handed barrow. This system is of course adopted only where the land is too soft to safely carry a horse, or where labour is abundant and wages are small.

Another method is to join the chains from two horses by a pair of stout ropes, travel a horse along each side of a row of coils, catch the coils by the rope connecting the horses, and sweep all that can be caught into the rick.

American Hay-collector. — A hay-collector invented in America is now much used in this country. This machine as now made is capable of collecting hay from the swathe, the coil, or shaked-out coils. One man with a pair of horses will bring in sufficient to keep from two to four men building stacks, and will leave much less to be gathered by the rake than by any other method yet introduced. This machine is about 12 feet wide, and rests on three light wheels, one on each side and another a few feet behind. To the under side of the framing of the machine twelve teeth 5 feet long are bolted. These teeth are of wood and pointed with iron, and are fixed about a foot above the ground. The driver, sitting on a seat above the hind wheel, can raise or lower the points of the teeth, whether loaded or unloaded, until they are a foot above the ground. On the outside of the apparatus, at each side of the teeth, a pole is placed, outside of each of which a horse is yoked to a plough-tree at one end of the pole and by a breast-strap or chain at the other. The points of the teeth being lowered in front of a windrow of loose hay or coils, and the horses guided down each side, the teeth slip under the hay until a load is gathered, when the driver lifts the points of the teeth from the ground, turns round his horses if need be, and carries off his load to the rick. Here he drops the teeth of the apparatus on the ground, backs his team, when the breast-straps of the horses pull the apparatus from under the load of hay, the points of the teeth are again raised, and the team move off for another load.

This apparatus is very light, being built almost entirely of wood, and very strong. It is said to be able to gather and carry from 4 cwt. to 7 cwt. of hay. It was introduced into Scotland by Mr John Speir of Newton in 1889, and since its introduction it has been more largely adopted in the south of England than in Scotland. In the former it is used principally for bringing the hay to the large stack, which in these circumstances is usually built at one side or corner of the field. When combined

with the elevator, the hay is brought from the windrow or coil, and delivered on the top of the stack, with remarkably little handling.

Preparing for Stacking.—If there is any dampness worth speaking of on the bottom of the coils, they should be turned upside-down an hour or so before stacking is commenced. In turning them over they should be turned so that the bottom faces the sun, and if the day is cloudy the bottom should be turned to the wind. As it is never advisable, even in good weather, to turn up a great many coils at one time, no more should be done than will just allow them to dry before being removed, an odd person going in front turning the coils over at or about the same speed as the crop is being stacked.

It often happens that mere turning of the coils upside-down is not sufficient to make the crop dry enough for stacking. In this case the rows of coils must be thoroughly shaken out, the space occupied by the spread hay depending very much on whether or not the crop requires much or little drying.

If the day is dull, or the crop more than usually damp, the coils not only require to be shaken out, but to be turned over with rakes or forks, in much the same way as the swathes are turned upside-down, before the hay is brought into the stack. Soft grown meadow hay often requires to be treated in this way, although it is very unusual to do so with timothy or clover and rye-grass. Where hay has been thus spread out, it should be gathered into narrower rows by hand-rakes or forks, or by the horse-rake, before beginning to stack, as the time thus spent is saved when stacking is begun, while the crop is drying all the time. If one or more persons can be spared to collect the scattered hay, this may be done as the stacking proceeds.

Ground for Stacks.—For the stacks, as dry and level a portion of the field should be chosen as possible. If the foundation be damp, the hay in the bottom of the stack is often considerably damaged, and if the land is not level it is difficult to build the stack so that it will not ultimately lean over to the low side.

Owing to soft places being in many meadows, it is also advisable to see that the stacks are placed in such a position that no difficulty will be experienced in getting the load out of the field. The position of the gates and water-courses must also be considered in selecting the positions of the stacks. These different obstacles, in the case of water meadows particularly, often necessitate departure from the rule already laid down as to building the stacks in a line across the rows of coils, and an equal distance from either end.

Work with the Wind.—Unless there is some reason for doing otherwise, a beginning with stacking should always be made at that side of the field from which the wind is blowing, as what is left after each stack is completed, and the rakings and dressings from it, can much more easily be conveyed to the next stack, when going with the wind, than when they have to be taken against it. Again, by this plan, hay which blows off the stack in course of being built is carried towards the next stack, whereas if building were continued in the opposite direction, the wind would always be blowing the loose hay on ground which had quite recently been raked, thus causing unnecessary work.

Building Field-stacks.—Little direction is required as to this. Some think it well to lay a foundation of straw, but this is not a general practice. When a few courses have been built, the stack should be tightly pulled at the very base, either by some one there for that special purpose or by the forker. Little taper should be given to the stack until four-fifths or five-sixths of the whole quantity intended to be put in the stack has been built. The stack may now be rapidly tapered, the forker or some other handy person in the meantime roughly smoothing down the stack with a rake. The rake should now be given to the builder, who, during the operation of building the head, should keep constantly raking the hay down. As the apex is reached, he should watch and put the hay only under his feet, and not at the sides, so as to have the centre as high and firm as possible. If the stack is intended to stand for some time, the top should be finished carefully, and the stack should be well roped.

In some cases, where the hay is not in good condition, the stacks are built without any one being on them—all the hay being placed in position by forks alone. To build stacks in this manner, two men working together make better work than where each works alone.

In early and dry localities the field-stacks, as a rule, are made much wider in proportion to their height than in higher and later districts. In the latter it is difficult to get the crop dry enough to keep well even in a narrow and very high stack. The shapes of stacks, like many other points in haymaking, vary in different localities.

Premature Stacking.—Hay stacked in too green a condition readily heats, occasionally moulds, and in many cases it loses its aromatic flavour and green colour, getting changed to a light-brown colour, with a musty sickening smell. The aromatic smell of hay may be preserved even where much heating occurs (as under the English system of haymaking), but in that case it must not have been stacked and dried in the field-stack—it must be taken direct from the coil or windrow. The same aromatic smell is often preserved in well-made silage under the heated or "sweet" silage process; but in this case it has a sweet flavour added to the original aromatic one. By many this flavour is supposed to be caused by sweet vernal grass; but well-made hay generally has it, although in many cases it may not contain a single blade of vernal.

Early *v.* Late Stacking.—There is now a pretty general consensus of opinion to the effect that it is better to be on the early than the late side with the stacking—that is, that of the two evils of early and late stacking the latter is the greater.

Straw and Hay Mixed.—The practice of interspersing imperfectly dried hay with layers of dried straw is pursued with good results in some parts, chiefly in wet districts. There is a twofold advantage in this plan. The excess of moisture in the hay is absorbed by the straw, and the interchange is beneficial to both the hay and the straw. The former is thus prevented from injury by heating, while as food for stock the straw is rendered more juicy and palatable. The proportions of this mixture may be 1 ton of straw to from 3 to 6 tons of hay, according to the condition of the hay as to moisture.

This plan is often adopted with advantage in saving aftermath.

Haymaking by Stages.

Whenever the first portion of hay has been secured in the stack, an opportunity is offered, if the weather is favourable, for advancing one stage further the different sections of the remaining work. To prevent hay being any longer exposed to the elements than is necessary, only as much should be in each stage as the available force of the farm can advance a stage further in a full day's work. Thus, if the weather were moderately favourable, and the crop from its nature could in the most of cases be coiled after exposure to the sun for from two to two and a half days, we would have the hay cut, say, on Monday, lying undisturbed in the swathe on Tuesday, turned on Wednesday morning as soon as the dew disappears, and coiled during the afternoon. On Wednesday night there would thus be a portion of the crop in three different stages of manufacture—viz., one portion cut that day, another partially dried which had been cut the day before, and a third in coil.

Unless the hay has been in all the better condition when coiled, it is rarely it can be put into the stack without standing at least one day and a half; and if the weather is dull or showery, it is quite uncertain how long it may have to stand.

Presuming, however, for the sake of illustration, that the weather has been favourable, this section of the hay crop which was coiled on Wednesday afternoon might be put into the stack on Friday afternoon or Saturday forenoon.

In the meantime an equal area should be cut and another coiled each day, and on Friday afternoon or Saturday three different sections will be advanced a stage—one will be cut, another coiled, and a third put in the stack; while of the other three remaining sections which have been cut during the week, and which are not touched to-day, one will be drying in the swathe, and two in the coil.

As soon as any one stage is ready to move on to the next, no time should be

lost in advancing it, as every stage the crop is moved forward it is the more secure. In a wet day the crop is always less damaged in the coil than had the same crop been in the swathe; and in the stack it may, practically speaking, be considered safe, although absolutely not so, as isolated persons occasionally find to their cost.

When the stacking stage of the process of haymaking has been attained, no more should be cut than there is a reasonable prospect of getting coiled on an early date. It is well to have little more in coils than can reasonably be stacked in from two to three days, as should unsettled weather set in, the intervals during which hay can be handled are often so brief, that where a small piece can be easily secured, a large area may be completely spoiled.

Hay-barns.

In many parts, particularly in dairying districts, it is the custom to put the hay crop, in whole or in part, into barns or sheds. These are usually buildings without sides, the roofs of which are supported on pillars, set wide enough apart to allow a cart loaded with hay to readily pass between them. Where the hay is to be used for the daily food of the stock of the farm, as it must be on the majority of farms, it is always advisable to have a considerable portion of the crop stored in sheds. For convenience, these sheds should be situated as close as possible to the byres, feeding-boxes, or other buildings in which the stock are kept. Stored in this way, the crop is always accessible in all kinds of weather, and is safe from injury from storms. The floor of the shed should be raised a few inches above the surrounding surface, and if possible filled with some dry material such as furnace-cinders, small stones, or gravel; and before any hay is laid down the bottom should be covered with some old dry straw, fern, or other rubbish. Failing this, rough boughs and branches of trees do well for keeping the hay off the damp ground.

The value of these hay-sheds, where large quantities of hay are grown, can hardly be overestimated. They have been provided very extensively in Ireland, where, upon medium and large holdings, the greater portion of the hay crop is preserved in this manner.

The hay-barns are now, as a rule, constructed entirely of iron, the roof consisting of sheet-iron, corrugated and galvanised. They are remarkably durable, and, in view of the great storing capacity afforded, the outlay is indeed very moderate. An excellent sample of the improved hay-barn (erected by A. and J. Main & Co.) is represented in fig. 570.

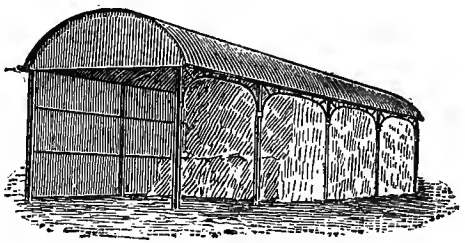


Fig. 570.—*Hay-shed.*

Permanent Hay-stacks.

Where hay-sheds have not been provided, the hay may be finally stored in round or oblong stacks either in the field or at the farm steading.

Foundation of Stacks.—A good, dry, level foundation for the hay-stack is a point of considerable importance. It is a good plan to have the ground upon which these stand permanently marked off by being raised a foot or so above the surrounding surface. In mining districts furnace-cinders are the best and cheapest material available for the bed of the hay-stack. Gravel and road-scrapings, or burned clay, are also suitable, and where neither of these can be easily obtained, the foundation may be raised by digging a small gutter round the base, and throwing the cleanings into the centre. Over this may be placed old pieces of wood, which, if covered with some old straw, prevent the hay from being spoiled to any appreciable extent. Branches of trees in the bottoms of stacks of grain are often objected to, on the score of their forming a harbour for vermin, such as mice or rats. These, however, rarely do any damage in a hay-stack, and tree branches are surpassed

by few other materials as stack foundations.

Bosses or Flues.—In permanent as well as temporary stacks, bosses, kilns, or flues are occasionally used for hay which is in a very indifferent condition.

Size of Stacks. — On small farms, where the available power for forking is generally not over-plentiful, round stacks of 12 feet in diameter will often be found large enough. If the hay is quite dry, it undoubtedly remains more palatable in a larger stack; but then the large stack entails extra labour and delay in forking.

The larger size of round stacks are usually made from 15 to 18 feet or even 20 feet in diameter, which, if of a corresponding height, are of twice or thrice the capacity of the smaller size of stacks, with a corresponding decrease in outside waste.

The oblong form of stack is very general. The dimensions vary in the main, in accordance with the extent of the holding, or rather with the area under hay. A common and convenient width is from 5 to 6 yards, and height from 8 to 16 feet to the eaves when settled down, while the length may range from 10 to 20 yards or more.

It is a common practice in many parts of the country, in England especially, to increase the width or diameter of the stack as it rises in height. One advantage of this is that wet dropping from the eaves falls on the ground clear of the sides of the stack.

Force in Building Stacks. — The size of the stack having been arranged in accordance with the power at the farmer's command, a beginning may be made in building. To keep the builders and others at the stack constantly employed, at least two hay-waggons or carts with harvest frames must be employed. Hay-waggons are much to be preferred to carts. Being longer and lower they are much easier loaded. Where the field is close to the stackyard, or other place of stacking the hay (it occasionally being stacked in the field it which it grows), one forker in the field will be able to keep both horses going, for while the one is loading the other is unloading. One builder will be required on the stack, who may have the assistance of three or four men, women, or boys to tramp or pack the hay, and throw it to him from the side on which the forker deposits it. Where another man can be spared, one should be put on to act as guide to the builder, who, while keeping the stack in proper shape as it is being built, throws up any loose hay, and may or may not put on the top on one stack while the builder is making the bottom of another.

Process of Building. — In building the stack the hay is first regularly laid in fork-loads over the whole bottom; the builder then puts on a ring of forkfuls all round the outside, taking care to throw the ends of the hay well out. While he is doing so, his assistant may put in other forkfuls of hay behind those he lays down, so as to form an inner circle, the forkfuls of the inner circle lying partially on the outer one, and holding them in position. The second row being finished, the centre should now be filled level with the outside circle, and on no account should it be kept hollow. The second and third courses should always project well over the first, after which the others should only project a very little. By following this plan less has to be pulled off the base to make it firm.

The trampers scatter the forkfuls of hay evenly over the surface of the stack, and the more carefully and thoroughly this scattering is done the more substantial and symmetrical will be the stack.

In this way the building continues until the eaves of the stack are reached, the person acting as guide all the while pulling off by his hand or the rake any hay which is loose or too far out. When the top is being formed, the person acting as guide will in all probability now require to go on the ladder and fork, as the top of the stack will be beyond the power of the carter to pitch the hay on to it.

High-forking by Hand.—When the stack gets too high for the forkers to be able to put up the hay, and no horse-fork or other similar appliance is available, a forking-stage of some sort must be provided. The following simple plan is pursued in some parts. The extra man mounts a ladder set against the stack, and taking the loaded fork out of the hands of the carter, at as great a height

as the latter can hand it to him, he is enabled to fork it several feet higher than can be done by the man on the cart.

To enable the second forker to get a good footing on the ladder, and yet to keep the latter as nearly straight up as possible, a stout plank about 8 or 9 inches wide and 4 feet or so long should be thrust through the spars of the ladder, above the spar where the man is intended to stand. By lowering the end of the plank nearest the stack, thrusting it through until it meets the hay, and then putting downward pressure on the outward end, it is brought into an almost horizontal position, which is quite safe and easy to stand on. Standing on the plank, with his back to the ladder, a man can hoist an ordinary forkful of hay without any danger of falling.

If the plank is not used, the inclination of the ladder must be much flatter so as to allow the man to stand on it easily and safely, and, in this case, his weight against a stack of any moderate size would almost certainly cause it to lean to the opposite side.

The use of the horse-fork or elevator, to be noticed presently, obviates all this difficulty.

Forking from Different Parts.—To prevent the stack leaning to one side, the forking should be done from as many positions as possible. By the continual dropping of the hay on one side, and the weight of the persons removing it always pressing down the hay at that place, the stack becomes more solid there than at the other side, with the result that when the stack settles down, no amount of propping will keep it from leaning over in the opposite direction.

Heading Stacks.—Before the top is begun to be formed, the whole outside ring should, as a rule, be made as level as possible. If the ground is slightly sloping (a position which should be chosen as seldom as possible), or if the forking has of necessity been all done from one side, then the eaves-ring on the opposite side should be left just a trifle higher than the other. In all other circumstances the eaves-ring should be level. The first ring of the top should be only slightly drawn within the eaves-ring, the second a trifle more, and the third a little more still, after which the decrease in width should be regular. As soon as the third ring and hearting have been completed, the builder should go round the whole top with a rake (fig. 571), and, with its head downwards, rake the top of the

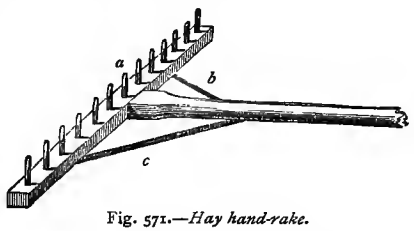


Fig. 571.—*Hay hand-rake.*
a Wooden teeth. *b c* Iron stays.

stack into proper shape. This done, the finishing of the top may be continued.

As the apex is approached, all should leave the top of the stack except the builder, who even alone will have barely room to stand. After laying on every couple of courses or so, he should carefully rake the roof. Towards the end the forker should be careful to put up only very small forkfuls, and at the finishing touches only mere handfuls. It is very desirable that this should be attended to, as in the building of a stack few things are more harassing or provoking to the builder than to have large forkfuls sent up, when there is not sufficient room for them.

The apex having been reached, the builder should carefully clear away any loose hay lying on the roof.

Roping Hay-stacks.—A couple of ropes should now be passed at right angles to each other over the top, and a half-brick hung to each end. Weights of any kind, hung to the end of the ropes, are much to be preferred to tying the end to the side of the stack. When the stack settles down, the tied rope becomes slack and does little good, whereas by the other method the strain on the rope is always the same.

Form of Stackhead.—When the head of a stack is built as already described, it should have the outline of an open umbrella: it should be flattest from the apex two-thirds down, and then more steep, because from the apex until half-way down the slope the thatch has little more rain to carry off than

falls on that particular part, whereas farther down the thatch has not only the rain which falls on itself to convey, but likewise the rain that has fallen on the part above.

By making the top of this form another gain is obtained. There is much less hay, proportionately speaking, in the narrow part under the apex, and as this part is often more injured by drying than any other portion, the form recommended reduces the loss to the minimum.

Large Stacks.—The building of large stacks is, of course, very similar to that of smaller stacks. Where more forkers than one are employed in the field, of course more carters will be required as well as more persons on the stack to receive it from them. As a rule, however, there is only one main builder, who puts on the outside courses, while there may or may not be another, who attends to the second or inside rings, while others spread and throw the hay across.

Propping Stacks.—In building either round or oblong stacks, particularly those small in diameter, short props should be put in whenever a height of 6 or 7 feet has been reached, and another set as soon as 10 or 12 feet is attained.

Height of Stacks.—The height of the haystack may be arranged to suit the taste and convenience of the farmer. It is contended by some that, as a rule, the eaves when built should be in height at least twice the diameter of the stack at the ground. Most farmers make their stacks much lower than this, because they are not possessed of sufficient power to put them higher; but when it is remembered that a high stack may contain twice as much hay as a low one, while the thatching is almost the same, the gain of having moderately high stacks will be obvious. This is more particularly the case when the extra height can be obtained at little or no extra cost, as where the horse fork is in use.

Improved Hay-stacking Appliances.

The stacking of hay has been greatly facilitated by the introduction of various ingenious appliances, such as stack-lifters and horse-forks.

Stack-lifters.—These appliances, designed for lifting stacks in the field and bringing them entire into the stackyard, have been in use for many years. They consist of a flat body, with shafts and tipping arrangements (similar to those in use on a tip-cart), mounted on two wheels 2 feet in diameter. Across the front of this low, broad, and flat cart is placed an iron roller, with lever and ratchet-wheel attached to one end. To the centre of this roller the ends of two stout ropes or light chains are attached, at the outer end of which are hooks for joining the one to the other.

When it is desired to put on a stack on this apparatus, the tipping arrangement is unlocked, the back end dropped on the ground, and the horse then backs it close into the stack. Meanwhile the attendant raises the hay forming the base of the stack from the ground, to permit of the edge getting better under it: the ropes are now unwound from the roller and passed round behind the stack, where they are joined and made firm, about 9 inches above the ground. The lever and ratchet are then brought into play, and the rope coiled on the roller. As the strain becomes greater on the roller, the edge of the stack-lifter is gradually pressed in under the stack. At about a foot or 18 inches under, it remains stationary, and as the attendant continues to wind in the rope, the stack is seen to move, and from that forward to glide gently up the incline until the front of the roller is reached, by which time the weight is generally heavy enough in front of the wheels to cause the body of the apparatus to drop down on the shafts, where it is locked.

This apparatus, if carefully worked, generally lifts all the stack without any trouble, brings it to the stackyard in its original position, and there, by unlocking the tipping arrangement, drops it in its former upright position. With this apparatus the bottom of a stack could be much more easily built than by first building the hay on carts, because from five to seven minutes is all that is required to draw a field-stack on to the lifter.

Defect in the System.—When, however, the stack became so high that one man could with difficulty pitch the hay on to it from the ground, it was found that little advantage was gained, because

two were required to fork in the stack-yard; whereas with carts, and one man in the field and the carter in the stack-yard, an equal height could be attained. For this reason, therefore, the original stack-lifters made little progress, and were to be found only on isolated farms.

Horse-forks.—In the spring of 1886 it occurred to Mr John Speir, Newton Farm, Glasgow, that this defect might be removed if this apparatus were strengthened and improved and used in connection with one of the many classes of horse-forks or elevators so largely used in America, and also employed on many farms in England and elsewhere in this country. He believed that double the value would be got out of each apparatus when combined that was possible when used separately, because the horse-fork could only do the forking in the yard, leaving that in the field to be done as formerly. With the stack-lifter, the field-forking was done away with, and with the horse-fork that in the stackyard was reduced to a minimum. Arrangements were at once made for procuring a couple of stack-lifters and a horse-fork of the most improved pattern, and after thorough trial, the results fully justified the anticipations which had been formed.

Types of Horse-forks.—Horse-forks are of various patterns. Most of them fairly well answer the purpose for which they were designed, but they are often found unsuitable where the circumstances are altered.

Clip-fork.—For lifting hay from solid stacks, preference is usually given to the clip-fork, the principle of which is the same as a mason or quarryman's shears for lifting stones by a crane, except that while the mason's shears have only one prong on either side, the hay-fork has two or three. When dropped open on to a portion of hay, the mere matter of the horse raising it forces the points together, a firm hold of the hay being thus secured. An arrangement exists by which the prongs can be pulled asunder at any instant by a person standing on the ground, so that the load of hay can be instantaneously dropped anywhere and at any time.

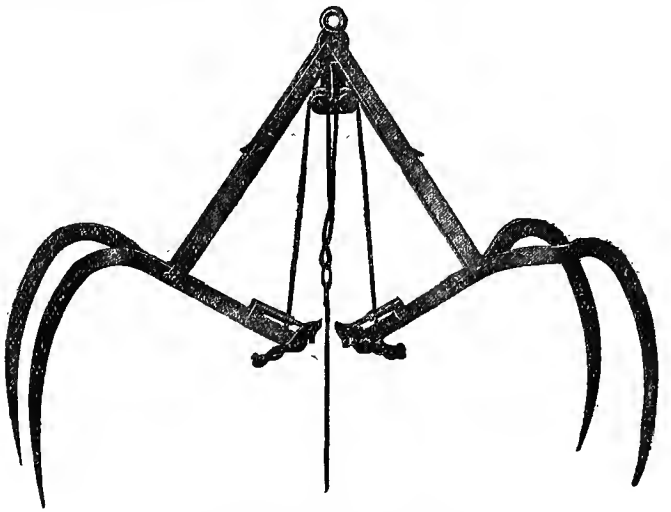


Fig. 572.—*Wallace's hay clip-fork (open).*

The working of Wallace's hay clip-fork is shown in figs. 572 and 573 (John Wallace & Sons, Glasgow).

Elevating Apparatus.—A simple and convenient arrangement for hoisting the hay is to have a pole about 35 feet high, which is held in upright position by three or four guy-ropes from the top of the pole to iron pins driven into the ground. A short "jib" or "gaff," 10 feet long or so, is arranged to slide up and down the pole, being worked by pulleys from the ground. The fork is attached to an inch hemp rope or ½ inch

steel strand rope, which passes over a pulley at the point of the jib or gaff, thence down the upper surface of the gaff to its lower end, where it passes over another pulley, from which it runs down the side of the pole to about 3 feet from the ground, where it passes through

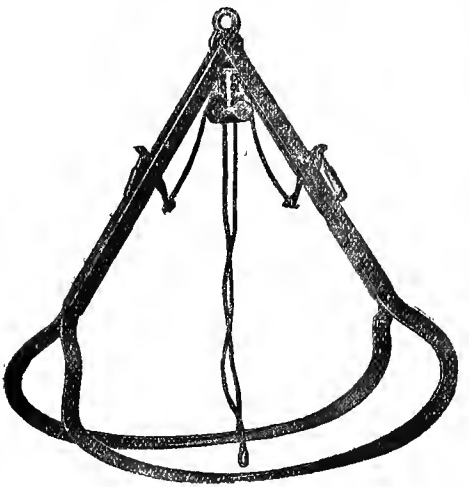


Fig. 573.—*Wallace's hay clip-fork (closed).*

the pole and under a pulley fixed in it, where it is attached to the tree or chains by which a horse draws up the forkful.

The pole is set up with a slight lean to the stack which is being built, so that as soon as the ascending load has been raised above the portion already built, the gaff or jib with its load always swings round over the top of the stack, where it can be dropped on almost any part of even a large stack.

Hay Elevator. — Many prefer the hay-elevator as shown in fig. 508, vol. ii., to the horse-fork in the stacking of hay. In stacking hay this elevator may be worked by a single-horse gear. The hay is thrown on to the bottom of the elevator and carried in a continuous stream to the desired height, the elevator being constructed so that its height can be varied.

Advantages of the Horse-fork. — The great speed in forking is not the only merit of the horse-fork. Stacks built by the horse-fork are more easily kept perpendicular than those built from hand-forking. With the horse-fork the forkfuls are regularly discharged only where they are wanted, and where the builder is working for the time being, so that the stack has not the same tendency to settle down at one side more than another, as it would have if the hay were forked by hand. A certain number of persons can also distribute regularly over the stack a much greater quantity of hay when forked by the horse-fork than by hand, because it is always dropped just where wanted, and they do not require to spend their time carrying it from one part to another.

A Good Day's Work. — The horse-fork can quite as easily lift hay from an ordinary hay-waggon or cart as from the ground; and where there are not as many stack-lifters as will keep it going, a portion of the hay, if desired, may be brought in by carts. On a moderate-sized farm each stack-lifter will bring in from 10 to 15 field-stacks per day, even where each may weigh from 15 cwt. to 20 cwt., the load being pulled on all the newer patterns by the horse instead of the man. Going a moderate distance, therefore, each carter may be supposed to be able to bring in about 10 tons of hay daily; and three stack-lifters, although they will be sufficient to bring in the hay of most farms, will not keep the fork going if there are sufficient people on the stack to build it. If three stack-lifters are in use, at least one man building, and three women or men spreading, will be required on the stack, one man will be necessary to act as guide, another will be required at the fork, and a woman or boy to lead the horse, while an extra woman will be required in the field to rake up the bottoms and assist in putting on the ropes. There are thus engaged six men and six women, who may bring from the field and build in the stack from 25 to 30 tons or over of hay daily—this, too, with very little exertion to any of them compared with what would be necessary were the hay lifted by hand-forks. A single horse-fork has been known to put up 50 tons of hay in one day.

Horse-fork Working in Sheds. — Where the hay is stored in sheds, and it is desired to use the horse-fork, a different

arrangement from that already described must be adopted. A stout wire, one half-inch in diameter, or double track of angle iron, is stretched tightly about a foot under the apex of the roof, from the one end of the building to the other. On this wire or other track runs a small carriage on two or four wheels, under which is a pulley. The double track and four-wheeled carriage is now in almost universal use, all other designs being gradually abandoned. The rope from the horse comes in at one end of the shed, passes up between guide-pulleys to the pulley under the carriage, over which it passes. In this case a pulley of a peculiar shape must be attached to the top of the fork, and the rope from the carriage passes under this pulley and back to the carriage, to which it is knotted. When the fork has been loaded, and the horse moves forward, the load is raised perpendicularly until the top of the pulley over the fork strikes a spring on the carriage, when a catch which has hitherto held it in position is released, and the carriage, with its load hanging from the under side, is pulled along the track till any particular division of the shed has been reached, whereupon the attendant drops the load and pulls back the fork. The arrangement is very neat, and admirable in working.

Although some modification of it is in use in almost every hay-barn in America, it for long gained little favour in this country. But after the combination of the stack-lifter and horse-fork was adopted in 1886 by Mr Speir, Newton, Glasgow, its use extended rapidly.

Horse-forks for Small Farmers.—In this country the capabilities of the horse-fork are as yet but partially understood. It has only been on the largest farms where, as a rule, they have been introduced; yet as a matter of fact they are a much greater gain to the small farmer than to the larger one. The small farmer could bring in the hay with one stack-lifter, unyoke his horse, and fork it up with the assistance of another person to lead the horse or build, as the person who leads the horse can easily enough work the fork also. Or, if more convenient, the small farmer may bring in two or three stacks, place them down as conveniently as possible, and then fork them afterwards. With the assistance of four persons in all, he may keep two stack-lifters going, have one person building and another at the fork, and neither of them need be able-bodied. The builder, indeed, is the only person requiring to exert much strength, as the horses load the stack-lifters as well as fork the hay.

Dressing Stacks.

After a hay-stack, or the hay stored in a shed, has been standing for three or four days, the sides should be carefully hand-pulled. Before beginning, all props should be taken away, so that the work may be more accurately done. The bottom or base of the stack should be pulled as firmly as possible, as the hay gets damaged very quickly if it is allowed to rest on the damp ground. Any parts of the sides which have a greater projection than the rest should be pulled down until the whole is uniform. If the stack has been well built at first, and has not been allowed to lean over to one side, the pulling is neither a difficult nor a tedious process. If, however, the stack has been badly built, is too far out at one part and too far in at another, or leans over in one direction, almost no amount of pulling will make it a good one. At most all that can be made of it is to give it a fairly respectable appearance, and reduce its outside waste as far as possible.

If stacks are not pulled after they have consolidated, there is usually much loose hay on the outside exposed to damage by the weather. On the other hand, if the stack is well built and carefully pulled, the loss is reduced to a minimum. After pulling, such a number of props should be returned as are necessary for the stack, considering its width, height, and accuracy of build. No more should be used, however, than are absolutely indispensable.

Irish Methods.

Besides the methods of harvesting hay just described, many others, differing from these in a lesser or greater degree, are pursued throughout the country.

In Ireland, where a very large area is occupied by the hay crop, there is great variety in the systems of haymaking.

The moist climate prevailing there compels the Irish farmer to resort to many devices to secure his hay crops in safety. In the natural meadows the tedder is employed freely, and as soon as at all possible this hay is put into tolerably large cocks or coils, and thence into the hay-barn—a valuable institution nowhere in this country so fully appreciated or so largely utilised as in the Emerald Isle. Rye-grass and clover hay is made, for the most part, as already described.

Often in Ireland the hay has, on account of the prevalence of drizzling rain and the absence of good drying weather, to lie long on the fields after it has been cut and before it can be stacked or stored in sheds. In this way more hay is unavoidably lost or injured in Ireland than in England and Scotland put together. By the employment of more expeditious and improved methods of handling the hay, and the introduction of the hay-barn for the storing of it, the loss in the fields has been very considerably curtailed. The hay harvest, however, is still a time of great anxiety to Irish farmers.

Rick-cloths.

The use of rick-cloths when stacking hay in the open field or yard is to be

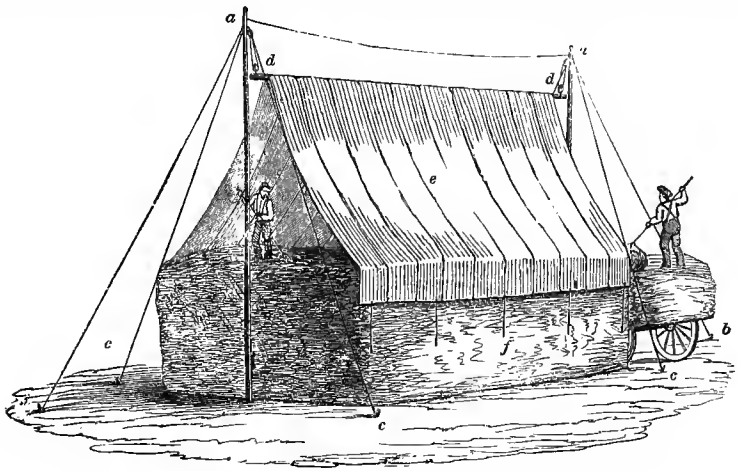


Fig. 574.—*Mode of erecting a rick-cloth over a hay-stack when being built.*

a a Wooden spars.
a to *a* Top-rope.
c c c Guy-ropes from side to side of a stack.
b b Guy-ropes from end to end of stack.
d d Blocks and tackle.
e Rick-cloth.
f Reef-points of cord.

recommended, especially in unsettled seasons and wet districts. One form of erecting these cloths, long pursued, is shown in fig. 574. Modern ingenuity has devised various methods of erection, more or less convenient. These cloths are of great service in protecting a partially built stack from showers of rain.

When a rick-cloth has not been provided, large waterproof tarpaulins should be at hand, to be drawn over unfinished stacks to protect them from a sudden downpour of rain.

Salting and Spicing Hay.

It is a common practice—and in many cases a good one—to scatter a little common salt amongst hay while it is being stacked. When hay is in a damp or badly made condition, in consequence of bad weather, salt is an excellent remedy against mouldiness. It is sown by hand by the builders upon every portion tramped down. The quantity used should correspond to the state of the hay, and must be left to discretion. Perhaps ¼ bushel to a ton is enough. Salt renders the ill-made hay more palatable to stock. "Hay spice," admirably suited for the sweetening of musty hay, is now offered by several firms. It is extensively used instead of salt, and is sown in stacking in the same way.

GROWING RYE-GRASS SEED.

In some parts of the country rye-grass is grown primarily for the production of seed. This is particularly the case in the province of Ulster in Ireland and the Scottish county of Ayr, where the bulk of the rye-grass seed produced in the British Isles is grown.

Methods of Growing and Handling Rye-grass Seed.—The methods pursued in the growing of the seed and in handling the seed are similar in Ulster and Ayrshire. A crop with much clover in it is not desired for the production of rye-grass seed, as in such cases the seed is generally small in quantity and less perfect in quality than where the crop is composed of rye-grass only. The crop is cut by the manual reaper, tied and stooked the same as cereals, only the sheaves and stooks are both smaller.

After the sheaves have stood a few days in the stook, they are put into small cocks, variously called "rickles" or "huts." In this condition the crop stands for from two to three weeks, when it is threshed or stacked. If for threshing, the crop is carted from the field to the farm or travelling threshing-machine, and after threshing, the hay is stacked in the ordinary way.

Instead of being threshed from the field, the crop is occasionally stacked in much the same way as cereals. This, however, is a wasteful practice, as the seed has such a tender attachment to the straw that a considerable proportion of it may be lost in the handling. "Rickling" or "hutting" is almost a necessity, as it is very difficult to get the seed sufficiently dry to keep unless the crop has been put up in this way for several weeks.

A certain amount of dressing is done to the seed by the growers, but it is all put through various machines which take out several weed seeds before it is offered for sale by the wholesale seed merchants.

Yield of Rye-grass Seed.—A fair yield of rye-grass seed would be from 26 to 30 bushels per acre. The weight of the seed per bushel usually ranges from 24 to 28 lb. There should be nearly 1 bushel of seed from each cwt. of hay.

The Flail for Threshing Rye-grass.—In some cases the flail is still used in threshing rye-grass, but it has disappeared from the greater part of the country. This antiquated and once most serviceable tool consists of two parts, the hand-staff or helve, and the supple or beater, fig. 575. The hand-staff is a light rod of ash about 5 feet in length, slightly increased in breadth at the farther extremity, where it is perforated for the passage of the thongs that bind the beater to it. The beater is a rod of from 30 to 36 inches in length, made of ash, though a more compact wood, as thorn, is less likely to split; and to prevent this disintegration of the wood the beater should be constructed to fall upon the *edge* of the segmental portions of the *reed* of the wood. The usual form of the beater is cylindrical, the diameter being from 1¼ to 1½ inch. For the most part it is attached to the hand-staff by a thong of hide untanned: eel-skins make a strong durable thong.

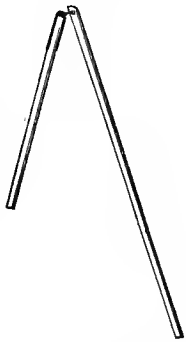


Fig. 575.—*Hand-flail.*

ARTIFICIAL HAY-DRYING.

Soon after the disastrously wet, sunless summer of 1879, a considerable amount of attention was given to the devising and testing of appliances for the artificial drying of hay.

Hot Air and Neilson Systems.—Two systems attained wide notoriety. These were Gibbs's hot-air method and Neilson's exhaust-fan system. The former, the invention of Mr Gibbs, of Gillwell Park, Essex, involved the use of a huge, unhandy apparatus, costing about £350. For the Neilson system, the inventor of which was Mr Neilson of Halewood Farm, near Liverpool, fans of numerous patterns were brought out, costing in most cases about £14 or £15. As is often the case with new devices, great hopes were raised by these inventions. They excited much interest and attracted many enthusiastic advo-

cates, who assured farmers that at last their trials and losses of harvest were at an end. Alas! it was little better than a dream. Both systems failed under the crucial test of practical work. They never came into general use, and have long since been given up.

PRESSING HAY.

The bulky character of hay renders it desirable that means should be provided for compressing it tightly into convenient trusses or bundles. In these trusses it can be more easily and more cheaply carried alike by road, rail, and steamer, than in its natural bulk.

Much ingenuity and enterprise have therefore been exerted in the devising of hay-presses — additional impetus being given to these efforts by the railway companies offering a reduced rate for carriage when 50 cwt. or more is packed on to an ordinary railway waggon. For this purpose, such pressure as will pack

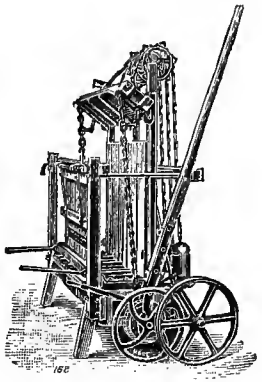


Fig. 576.—*Hay and straw hand-power press.*

nearly 8 lb. of hay or straw into a cubic foot is sufficient.

At various times trials of hay-presses have been conducted throughout the

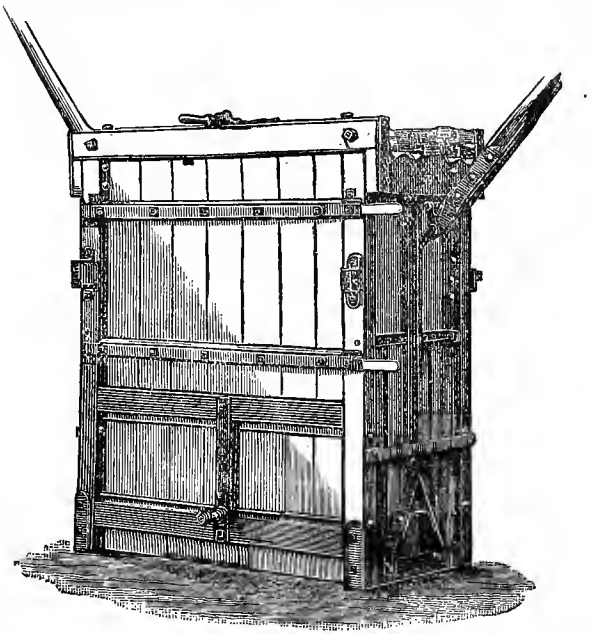


Fig. 577.—*Morgan's hay- and straw-press.*

country, and in this way several efficient appliances for the purpose have been brought into notice. Large presses for steam-power have been introduced, but smaller presses for horse- or hand-power are more widely used. A combined hay- and straw-press for hand-power, made by Barford & Perkins, Peterborough, is shown in fig. 576. Morgan's hay- and straw-press is represented in fig. 577.

THE MANAGEMENT OF PASTURES.

Insufficient Attention to Pastures.—In view of the falling off in corn culture, greater importance is nowadays attached to the grazing division of the farm than in former times. It is therefore especially unfortunate that the majority of the farmers of the United Kingdom do not give sufficient attention to the management of land under grass. Often, indeed, it would seem to be thought by those who have not adequately considered the subject that pastures may be largely left to take care of themselves. A greater mistake could hardly be made. Not only does the management of pastures require capable and careful attention, but few departments of the farm will, as a rule, better repay proper care when it is bestowed. The difference between good and bad farming may be seen very strikingly in the condition of grazing land; and it has to be confessed that in many parts of this country appearances in this respect are far from what they ought to be.

Too frequently one sees pasture-land strewn with destructive weeds which are rarely timely or effectually cut down. Lack of attention to surface-water runs or underground drains often greatly lessens the value of pastures. More skilful treatment in manuring is also required, while, generally speaking, there is room for improvement in the methods of grazing by different classes of stock.

Pastures on Different Soils.—In the management of pastures the character of the soil has to be carefully considered. Pastures lying on good soils usually tend to improve, whereas those lying on poor soils, as a rule, deteriorate, unless maintained by manuring or other remedial treatment. The best pastures carry a feeding stock which return valuable manurial ingredients in the droppings, whereas the poorer pastures are usually grazed by either a growing or a breeding stock, by which much more of the elements of fertility is removed from the land.

Generally speaking, the stronger classes of soils make the best pastures. A strong clay soil, when under cultivation, is often either somewhat baked or puddled, whereas, when the same soil is under pasture, the better conditions of tilth which it obtains, as a result of successive winter frosts not being interfered with by implements, are retained by the soil. It is therefore advisable that, as far as this can be controlled, the permanent pasture of the farm should be on the stronger soils, and that the lighter class of soils should be under cultivation, assuming, of course, that the quality of the latter is good enough for the required purposes.

Effect of Climate on Pastures.—Climate is a most important factor in connection with pasture. The best grazing districts in Britain are to be found where the rainfall is fairly abundant and well distributed, where the sunshine is not excessive, and where prolonged frosts or droughts are rare. The western counties of Britain have more rainfall, cooler summers, and milder winters than the eastern counties, and as a result the former are much better suited for grazing than the latter. The pasture advantages of the western counties are shared to a still greater extent by nearly the whole of Ireland, a result which gives that country the name of the Emerald Isle. On the other hand, the smaller rainfall of the south-eastern counties of England and of the counties around London, combined with the warmer summers and colder winters of these counties, give unfavourable conditions for pastures, especially when they are lying on a subsoil of sand or chalk. It is under these latter conditions that the greatest difficulty is experienced in laying down land to pasture.

Pastures should not be Mown.—A pasture, like a lawn, should be regularly rolled and kept close down, but the rollers and mowers of a pasture should be the grazing stock. A pasture that carries a heavy stock has, therefore, a great advantage over that which supports a light stock. The custom in the midland and southern counties of Eng-

land to occasionally take a hay crop from pasture-land tends to make the herbage coarse, as the growth of the hay injures the close bottom herbage, which is so essential to a good pasture. For this reason also a pasture should never be allowed to become coarse and benty, and it is very advisable that it should be grazed bare at least twice every season. Permanent pasture, therefore, if it is to be made the most of for grazing purposes, should never be mown for hay. In many cases when pasture becomes unusually rank and coarse, benefit is derived by running a high-set mower over it in the autumn, but this is very different from taking a full crop of hay from the land.

The Prospects of Profit from Pastures.—A question that must always be considered is a profitable return from the outlay in improving pasture. Before land became depreciated in value, operations like draining and liming were considered to be essential in commencing the improvement of poor clay soil. It is now possible, however, to purchase clay land in Essex and other counties at a considerably less price per acre for the freehold than would cover the cost of draining and liming such land. Under present conditions, therefore, these operations should be carried out only if they are likely to give a profitable return, and full consideration should be given as to whether either of these operations is actually necessary.

Drainage of Pastures.—When a pasture is wet and in a marshy condition, drainage in some form or another is essential. At the same time, care should be taken not to *overdrain*, as there is no doubt that large areas of pasture-land have been injured by doing so. In a dry season a fair supply of subsoil water is of great importance.

Manuring of Pastures.

The manurial ingredients usually required by soils which are naturally poor, or have been reduced in fertility, are four—namely, nitrogen, phosphates, potash, and lime. It has long been known that lime not only acts as a plant-food, but that it has a great value in making other plant-food in the soil suitable for the growth of plants. Recent and extensive manurial trials, however, on all kinds of pasture have shown that lime in a great many cases not only has little effect in improving pasture, but that when applied with certain other manures it may retard their action. It has also been claimed for lime that it is a most effective agent for removing moss in pastures, but this has been proved by experiments not to be so. Moss is most easily got rid of by encouraging good pasture-plants, and therefore the system of manuring that will improve a pasture to the greatest extent is the best means of removing moss.

The manurial requirements of pastures may thus be shortly summed up:—

(1) Manures containing phosphates—*i.e.*, superphosphate, bones, basic slag—are of the first importance, as phosphates are most likely to be exhausted to the greatest extent by the grazing stock.

(2) As pastures improve they tend to become richer in nitrogen, and to enable them to do this the encouragement of clovers and other leguminous plants in the pasture is all important. This can be most effectually done by the judicious use of phosphatic manures with the addition of manures containing potash and lime if necessary.

(3) A potash manure is usually not needed on the heavier classes of soils, but is likely to be an essential adjunct to phosphates on the lighter soils, especially if recently laid down. The grazing stock return practically all the potash to the land in their droppings, and for the same reason dung is rich in potash. Old pastures, therefore, which have a rich covering of black organic matter, or pastures on which dung has been freely applied, are not likely to respond to a potash manure, even when lying on a somewhat light soil.

(4) Lime will in most cases give its best results when applied in small quantities per acre, and in a condition that it can be thoroughly distributed. This is undoubtedly one of the reasons that basic slag is so effective on many of our old pastures, for the large percentage of lime that slag contains is invariably well spread over the land. Ordinary dressings of lime have been tried with unfavourable results on poor clay in Northumberland and Cumberland, on poor sandy soils in Northumberland

and Dorset, and on both classes of soils elsewhere, and yet in all cases the soils were poor in lime. Even on peaty soils in Cumberland ordinary lime has not been very effective. In practically all these cases, however, basic slag has given excellent results by itself on the clay soils, and when accompanied with a potash manure on the sandy and peaty soils. There can be no doubt that basic slag acts not only because of the phosphates, but because of the lime that it contains. Further, the use of basic slag makes the application of either common lime or ground lime unnecessary on the great bulk of pastures. It is only soils of a peaty character, or those with a good deal of rough, matty herbage, that are likely to give a good return from these forms of lime. The results of recent experiments in Germany, especially on peaty soils, fully corroborate the foregoing conclusions. In fact, for pasture as well as for most other purposes, lime may be effectively applied in quantities not greatly exceeding that of the other manurial ingredients, provided it is in a fine condition, so that it is thoroughly distributed in the soil.

Great care must be exercised in applying either nitrate of soda or sulphate of ammonia to pastures. These manures diminish clover herbage, make the grass much more benty in character, and ultimately, as a rule, tend to reduce the feeding value of the herbage.

Feeding Cake on Pastures.—The cakes usually fed to stock grazing on pastures are decorticated cotton cake, undecorticated cotton cake, and linseed cake. Voelcker and Hall (1902) give the residual manurial value of a ton of each of these as 56s. 5d., 33s. 9d., and 38s. 7d. respectively. The values attached to the nitrogen in each are 41s. 5d., 21s. 3d., and 28s. 6d. per ton respectively, so that, roughly speaking, nitrogen accounts for three-fourths of the residual value of decorticated cake and linseed cake, and for nearly two-thirds of that of undecorticated cotton cake. There can be no doubt that the feeding of cake to grazing stock, if judiciously done and in moderation, is a very effective method of improving pastures. As, however, cakes contribute nitrogen to the soil principally, and only a small amount of phosphates, pastures cannot be effectively improved by this means only, as the main requirement, phosphoric acid, is not in this way applied in anything like sufficient quantities.

The feeding of cake improves a pasture, not only because of its manurial residue, but because a heavier grazing stock can be kept, and this has a most valuable result in keeping the pasture finer and closer at the bottom. When cake, however, is fed beyond moderate quantities on pasture, the herbage becomes more benty in character and clover decreases, no doubt owing to the nitrogen contained in the cake residue.

Caution in using Cakes on Pastures.—But while the consumption of cake upon the land may usually be an effective, it does not always follow that it is also an economical, method of maintaining pasture. It is both, as a rule, where the conditions as to soil and climate are favourable; but the matter is very different when both soil and climate are backward, where the soil is so bad as to yield produce deficient alike in quantity and quality, and where the rainfall is so large that the loss of plant food in drainage is exceptionally heavy. In these latter circumstances cakes have to be used on pastures with the utmost care to ensure profit.

Suggested Dressings of Manures.—A poor pasture lying on a poor clay soil will probably be effectively improved by the application of 10 cwt. basic slag per acre. This should contain not less than 37 per cent phosphate of lime, and if so, 10 cwt. slag will contain about 170 lb. phosphoric acid per acre. If the slag is poorer in quality, the dressing should be correspondingly increased. Eight cwt. of finely ground bone-meal might be applied instead of slag, but this is likely to be slower in its action, and has not the advantage of the free lime contained in the slag.

A dressing of half the quantity of slag might be repeated every three years thereafter, and the feeding of cake to the grazing stock will probably assist the improvement in the earlier years. There is now ample evidence to show that the good effects of slag will continue after repeated dressings. If the soil is of a sandy or a peaty character, 2 cwt. an acre of muriate of potash (50

per cent potash), or 6 to 8 cwt. kainit, will probably be useful in addition to the first dressing of slag, along with half of either of these quantities with the later dressings.

For soils rich in lime, superphosphate will probably be more effective than basic slag, but it is not advisable to apply more than 5 cwt. per acre of this manure in one dressing.

Application of Manures. — Basic slag, bone-meal, and the potash manures are best applied in the autumn or early winter, while superphosphate is probably best applied about February. As slag is ground to a very fine state of division, it should always be applied by itself and not mixed with other manures, as the same perfect distribution will not be secured as when the slag is sown alone. Superphosphate should be in a fine and friable, and not in a pasty, condition. Bone-meal should be finely ground, and manures like kainit and muriate of potash should have all lumps larger than shot broken into a fine condition. A pasture should always be closely eaten down if possible before the manures are applied. If rough and in a benty condition it should be subjected to a heavy harrowing, and, if necessary, it should be mown, otherwise the effects of the manures will be retarded. The sowing of the manures, preferably by a machine, should be efficiently and thoroughly carried out.

Stocking of Pastures.

The overstocking of pastures greatly reduces the total amount of herbage produced, especially in a dry season, as when the sward is bare the bad effects of drought are greatly increased. Understocking, however, does even more harm, as the herbage becomes coarse and the fine grazing plants are greatly reduced. Wherever possible, pasture fields should be grazed in rotation, so that each field is grazed for a few weeks and rested for about a fortnight alternately. At least twice each season pastures should be closely eaten down. When pastures are saved for winter foggage, care should be taken that all the rough herbage has been eaten off by the beginning of May.

Horses are the worst stock for pastures. They deposit their droppings only on certain parts of the fields, and on these they never graze. On the other parts they graze very closely, which they can do, as they have incisor teeth on both jaws. A pasture, therefore, grazed by horses only, soon becomes very unsightly —coarse and tufty where their droppings are deposited, and poor and bare where they do graze. On this account horses should never be grazed for long on the same field, but should be kept moving round the different fields. Cattle have no incisors on the upper jaw, and cannot graze nearly so closely as horses. Their manure is dropped all over the fields they graze, although each dropping is not so well spread as the droppings of sheep. Cattle are the best stock for the grazing of a pasture.

Sheep, like cattle, have no incisors on their upper jaws, but they bite more closely, partly because their lower lips are cleft. By means of their small mouths they select the fine bottom herbage and reject that of a stemmy character, so that a pasture grazed by sheep only soon becomes of a benty character. Sheep do best when grazing as a mixed stock with cattle, but as the latter do not bite so closely they lose much of the finer and more nutritious herbage when sheep are grazing with them, and cattle, therefore, do better when grazing by themselves than with sheep.

Sheep droppings are distributed much more evenly over the land than either those of cattle or horses. The spreading of the droppings of horses and cattle by harrowing is a very desirable operation, and where convenient should be done both in autumn and in spring. Where horses are the principal stock, their droppings should be collected and spread on the bare parts of the field or on other pastures.

Pasture recently laid down should be closely eaten in the early summer, especially if rye-grass has been largely sown, otherwise this grass will "run to seed." Young pasture is always earlier in spring than old pasture.

The best quality pastures are usually reserved for feeding animals, while secondary or inferior pastures are grazed by young or growing, breeding, and milking stock.

As feeding animals are usually full

grown, they exhaust pastures to a very small extent, whereas young or breeding or milking stock all considerably exhaust the pastures, especially in phosphates. It is therefore clear that a really good pasture has a much better chance of retaining its character than a poorer pasture, and this partly explains why such a pasture may not require any manurial treatment when a secondary or inferior pasture may frequently do so.

Cows in milk rapidly impoverish a pasture, and still more so if they graze on it during the day only, and are housed at night, as, when this is so, considerably less than half of their droppings is left on the pasture.

Water-supply. — Cattle and horses must always have access to water when they are grazing. This is necessary also for sheep in a dry season, but they seldom drink water in showery weather. A running stream is by far the best supply, but if this is not available, the ponds should be of sufficient size to contain water to last throughout a dry season. These should always be approached by a hard bottom, as otherwise the water soon becomes dirty. Where running water is not available a gravitation supply should be secured if at all possible. The progress of grazing stock is very much retarded by a bad water-supply, and now that so much attention is being given to a proper water-supply for milch cows by sanitary authorities, this has become an important question to dairy farmers.

Weeds.—Thistles and docks are the most troublesome of the larger weeds. These should be cut or hoed out twice in each season. When the soil is fairly moist docks should be pulled out by the roots. The best time to cut thistles is when the flower is beginning to form, as the roots are now weaker than when the plants are only a few inches above the ground, and they are not yet mature enough to produce seed. The common thistle spreads principally by underground stems, which make this plant much more difficult to eradicate, while the Scotch thistle is produced from seed only, and is therefore more easily dealt with. The smaller weeds, such as daisies, buttercups, sorrel, and plantains, can be effectively checked by judicious manurial treatment and the proper grazing of pastures.

Drains and Fences. — All ditches should be regularly cleared once a-year, and the outlets of field drains entering into them should be examined to see that they are clear and properly trapped to prevent the ingress of vermin. Fences need regular attention, and should be at once repaired when they are injured by the grazing stock, or have become deficient from decay. There should be a clear understanding as to the upkeep of tenant's fences, landlord's fences, and march or boundary fences.

On many estates a large extent of pasture is let annually. In these cases the landlord usually provides for the fencing, the manurial treatment when necessary, and also for a certain amount of supervision of the grazing stock, and he pays all rates and taxes. The annual rent paid for such pasture is therefore an inclusive one, and is considerably higher than is paid under ordinary farming conditions. It is also fairly common to allow for the manurial value of cake fed to the grazing stock.

Grazing after a Hay Crop.—The "aftermath," or foggage, which follows a crop of first year's hay may have a considerable value for grazing, especially if clover is abundant. Foggage of this character is frequently let for eating off by lambs in Scotland and the North of England, and usually makes the equivalent of from 3d. to 4d. per lamb per week. A good aftermath should carry five lambs an acre for eight weeks in the autumn, and would thus be worth from 10s. to 12s. 6d. an acre. If very good it would be worth more, and if poor, considerably less. The aftermath of a second and third year's hay has a considerably less value, as well as that of old land hay.

Recent experiments have shown that the aftermath of old land hay has a greater feeding value when neither nitrate of soda nor sulphate of ammonia is used for the hay crop.

Value of Pastures. — The annual value of a pasture varies from a few shillings to over £5 per acre, and its value can be enhanced or reduced to a much greater extent by good or bad management than land under cultivation

for ordinary farm crops. A first-class pasture will feed a good bullock on each acre, and may even feed two in succession in one season. On secondary pastures one and a half acres, and even more, may be required per beast, with cake in addition if fattening is the object. On the poorer pastures the amount of stock carried is considerably less, and these will be kept in store condition only.

In vol. i. pp. 340-346, information is given as to methods of laying poor land down to pasture, and of renewing and improving hill pasture.

FORMATION OF PERMANENT PASTURE.

At pp. 245-247 information is given as to grasses and clovers and standard mixtures of seeds suitable for permanent pastures. As already indicated, the low prices for cereal crops and high rates of wages now prevailing in this country have led to great importance being attached to the maintaining of land under grass, and on this account it is thought well to introduce here some additional information regarding the laying of land down to permanent pasture. In the first place, some supplementary notes may be given as to special seed mixtures which have been experimented with.

Most important Grasses and Clovers for Permanent Pasture.—The most important of the grasses for permanent pasture are meadow fescue, timothy or catstail grass, cocksfoot, meadow foxtail, and perennial rye-grass. While the clover best suited for this purpose is wild white clover, which has a more perennial character than the common white clover of commerce, a certain proportion of other clovers should be included to give good herbage in the first few years.

Trials in Northumberland.—From trials that have been made in connection with Armstrong College, at Cockle Park, Northumberland, it has been found that the following mixtures per acre have given promising results, both as to hay in the first year and as to pasture afterwards.:—

	Cost of Seed.	Mixture. No. 1. lb.	No. 2. lb.	No. 3. lb.
Perennial rye-grass	4s. 6d. per bush.	6	6	...
Italian rye-grass	5s. 0d. "	6	6	...
Cocksfoot	9d. per lb.	6	6	12
Timothy	4d. "	3	3	3
Meadow fescue	6d. "	8	8	6
Tall fescue	1s. 3d. "	...	...	4
Tall oat-grass	1s. 0d. "	...	...	4
Red clover	8d. "	4	4	4
Alsike clover	9d. "	2	2	...
White clover	9d. "	4	...	...
Wild white clover	1s. 8d. "	...	4	4
		39	39	37
	Cost of seeds per acre	19s.	22s. 8d.	31s. 4d.

Trials in Cumberland.—At Whitehall, Cumberland, the following mixture, at a cost of 29s. an acre, gave excellent crops of hay in the first two years after sowing, and resulted in an excellent pasture: perennial rye-grass, 9½ lb.; cocksfoot, 5 lb.; timothy, 3 lb.; meadow fescue, 13 lb.; rough-stalked meadow grass, 1 lb.; cow-grass clover, 2½ lb.; alsike clover, 2½ lb.; white clover, 5½ lb.; yarrow, ⅓ lb. Although in the third year cocksfoot was present to the extent of 40 per cent, the pasture was closely grazed, and was not at all coarse. It was found that rough-stalked meadow grass had not been of value, and at any rate was not present at that time. It is likely that meadow foxtail might have been

added to this mixture with advantage. This grass, however, will probably develop satisfactorily on rich loam soils only.

The three Cockle Park mixtures and the Whitehall mixture are good examples of different types of mixtures at a reasonable cost. Cockle Park No. 1 mixture has proved excellent so far as grasses are concerned, but not one of the clovers has proved to be permanent. Cockle Park No. 2 mixture is much more promising in its results, as the 4 lb. of wild white clover included has given a close bottom herbage of this plant, which promises to be perennial, or at least to be so until natural plants of white clover have developed themselves. In both these mixtures Italian rye-grass has been included to give bulk of hay in the first year. Cockle Park No. 3 mixture excluded the rye-grasses, and although the hay crop was not as heavy in the first year, it was a fairly satisfactory one, while the promise of the herbage for hay or pasture was encouraging. The Whitehall mixture has resulted in an excellent pasture in six years after sowing, while it also gave excellent hay crops in the first two years, and grazed well immediately afterwards.

These are good inexpensive mixtures which may form a useful guide to farmers who wish to lay down their land so as to take one or two crops of hay and then follow with pasture. The soil at Cockle Park is a poor boulder-clay in an exposed position, while that at Whitehall is a strong loam of a good character.

Wild White Clover.—The wild white clover is obtained from meadows in the south of England, where it grows as a naturally wild plant. Care should be taken that the seed has been obtained from true wild plants.

Trials in South of England.—In the southern counties of England the following mixture of seeds was found, in trials conducted by the University College of Agriculture at Reading, to give excellent results:—

	lb. per acre.		lb. per acre.
Perennial rye-grass	10	Cow-grass clover	1
Cocksfoot grass .	2	Alsike clover .	2
Timothy grass .	2	Lucerne . .	10
Tall fescue grass .	2	Sainfoin (seed in the husk) .	10
Trefoil . .	1		

Cost about 21s. per acre.

This gave good results as a mixture for a few years' lea on gravelly, sandy, and loamy soils, but was not so suitable for stiff clays. The trials showed that, under suitable conditions, sainfoin, and especially lucerne, make excellent plants for including in such a mixture. This mixture was tested alongside several other mixtures, and gave the best results under the foregoing conditions.

Local Circumstances to be considered.—But, as already pointed out more than once, farmers must use their own judgment in the making up of seed mixtures, as in the choice of manures. The local circumstances as to soil and climate are variable, and these must be carefully and intelligently considered if the best possible results are to be secured.

Sowing Permanent Pastures.

Sowing Grass Seeds without another Crop.—When grass and clover seeds are sown without a crop, there is no risk of their being killed out by a "laid" or lodged cereal crop, and there is a better chance of the grass and clover plants being well established in the year of sowing. When this is done it is usual to sow a small amount of rape or mustard with the seeds. It is the exception, however, to sow grass and clover seeds in this way.

Sowing Grass with another Crop.—The prevailing practice, as has been seen, is to sow grass and clover seeds with a corn crop, now most commonly barley or oats, in most cases which ever happens to be the crop grown after roots or potatoes. This corn or clover crop acts as an excellent check for weeds in the first year, and gives a good return to the farmer, which, if partly expended on the manuring of the young seeds, will give an excellent result if the manures are properly chosen. Such a corn crop should never be top-dressed with an active nitrogenous manure, and if in spite of this it is likely to lodge, it should be cut early so as to prevent damage to the young seeds. Land should always be clean and in good tilth on which young seeds are sown, so that the proper time for sowing them is with the corn crop which succeeds a fallow or fallow (root or potato) crop.

When the corn crop has been harvested, a dressing of 5 cwt. basic slag an acre, or

an equivalent of some other phosphatic manure, will be useful; and to this should be added a potash manure (say 1½ cwt. muriate of potash an acre) if the soil is of a light sandy character.

Hay Crop from Permanent Grasses.—In the following year many prefer to graze their seeds and not to mow them as hay, but the roots of the young plants will be better developed if a crop of hay is taken. This, however, should be cut about ten days earlier than seed hay is usually cut, as by doing so the roots of the grass and clover plants retain considerably more vitality when the plants are cut before they begin to mature their seeds.

Early Grazing of Permanent Grass.—The field should now be regularly and judiciously grazed, and care should be taken that it is always well eaten down in the early summer. This is especially important if perennial rye-grass has been included in the mixture, owing to the tendency of this grass to run to seed. The hay crop must not be top-dressed with nitrogenous manures like nitrate of soda or sulphate of ammonia, as if so clovers will be checked and the grass will not make as good grazing herbage afterwards.

In laying down wet stiff clay soils to pasture, it may be advisable to mow the field for the first two years and not to pasture it, so as to give time for the soil to become firmer, and so stand better the treading of the grazing stock.

Manures for Permanent Pasture.—Another dressing of about 5 cwt. of basic slag or some equivalent may be repeated in the autumn three years later. If the soil is of a light character, the formation of a sward of pasture will be greatly assisted by a dressing of 10 to 12 tons dung an acre in the autumn after the first crop of hay has been removed; in fact, such a dressing will be found very useful for any young pasture. Active nitrogenous manures will not be required if clover plants are produced and maintained, as the roots of these collect nitrogen from the air. Instead of slag, finely ground bone-meal may be used as the phosphatic manure, 4 cwt. of this being used instead of 5 cwt. slag. It must be remembered, however, that slag contains a considerable amount of free lime, and this, with its fineness of grinding, gives it two distinct advantages over bone-meal. But on certain soils, especially on those which have a fair proportion of lime, bone-meal may give better results. There is no doubt also that bone-meal can always be relied on in the long-run.

Fairy Rings in Pastures.—What are known as "fairy rings" in permanent pastures are so called because of the supposition prevalent in olden times that the circles were formed by fairies in their nocturnal dances. The rings are caused by fungi, which spring up at random. The fungus grows outwards from a centre, and spreads wider year by year, the decay of each season's growth of fungus bringing up a gradually widening ring of grass exceptionally fresh and green. The rings do little or no harm in pastures, but disfigure ornamental grounds. In the latter the fungus should be dug out immediately it is observed at a centre, and not allowed to spread. By breaking and forking-out the fungus two or three times a-year, just when it begins to show above-ground, the rings may be prevented from becoming very prominent in appearance.

Clifton Park System of Growing Grass.

The system of growing grass introduced by Mr Robert H. Elliot, owner of the estate of Clifton Park, in the Scottish county of Roxburgh, has attracted much attention. The main object aimed at by Mr Elliot was to sow such deep-rooting plants as would increase the amount of vegetable matter in the soil, and thus raise its fertility. His practice in laying his land to grass has been to sow for this purpose chicory, burnet, kidney vetch, and yarrow, along with natural grasses and clovers. Mr Elliot has not only obtained excellent pasture from these seeds in average seasons, but also in exceptionally dry years, when the deep-rooted plants show wonderful drought-resisting properties. Moreover, when broken up, the soil is found to be greatly increased in productiveness. Mr Elliot has published a full account of his system in the form of a small volume, which is well worthy of perusal.

In a new edition of this volume, published in 1907, Mr Elliot recommends the following as an "improved mixture" of seeds, adjusted in accordance with his "experience of the last twelve years":—

Improved Kaimrig Selection.	Quantity of Seed per acre.	Guaranteed germination.	Number of germinating Seeds per statute acre.	Price.
	lb.	per cent.		s. d.
Cocksfoot (*Dactylis glomerata*)	10	95	4,047,000	12 6
Meadow fescue (*Festuca pratensis*)	5	97	1,144,600	4 7
Tall fescue (*Festuca elatior*)	4	97	954,480	6 0
Tall oat-like grass (*Avena elatior*)	3	94	389,160	3 0
Hard fescue (*Festuca duriuscula*)	1	95	549,100	0 8
Rough-stalked meadow grass (*Poa trivialis*)	½	96	1,072,800	0 10
Smooth-stalked meadow grass (*Poa pratensis*)	1	75	1,395,000	1 4
Golden oat-grass (*Avena flavescens*)	½	80	560,000	1 9
Italian rye-grass (*Lolium italicum*)	3	98	793,800	1 0
White clover (*Trifolium repens*)	2	98	1,434,720	2 0
Alsike clover (*Trifolium hybridum*)	1	98	703,640	1 1
Late-flowering red clover (*Tri. prat. per var.*	2	98	427,280	2 8
Kidney vetch (*Anthyllis vulneraria*)	2½	98	472,850	2 6
Chicory (*Cichorium intybus*)	3	90	904,500	3 6
Burnet (*Poterium sanguisorba*)	8	130	561,600	4 8
Sheep's parsley (*Petroselinum sativum*)	1	85	195,500	0 6
Yarrow (*Achillea Millefolium*)	½	90	1,579,500	3 0
	48	...	17,185,530	51 7

Permanent Pasture on Poor Clay Soil.

In the *Journal of the Board of Agriculture* for October and November 1905 (Nos. 7 and 8, vol. xii., New Series), the "Formation of Permanent Pastures" is discussed by Professor T. H. Middleton. As an adaptation of the seed mixture used by Mr Elliot of Clifton Park, with the cost of the seed restricted to about £1 per acre, Professor Middleton suggests the following mixture for the formation of permanent pasture on poor clay land:—

Seeds Mixture for Laying Down Poor Clay Soil to Permanent Pasture per Acre.

Plant.	Weight.	Number of Seeds in Thousands.	Cost.
	lb.		s. d.
Italian rye-grass	4	1,069	1 1
Perennial rye-grass	3	635	0 7
Timothy	1	1,307	0 6
Cocksfoot	2	809	1 10
Meadow fescue	2	467	1 2
Tall fescue	½	120	0 5
Hard fescue	1	555	0 6
Meadow foxtail	1	441	1 2
Tall oat-grass	½	62	0 6
Golden oat-grass	¼	280	0 8
Rough-stalked poa	¾	1,626	1 2
Smooth-stalked poa	¾	1,085	0 6
Crested dogstail	¼	210	0 9
Perennial red clover	1½	320	1 5
Alsike clover	1½	1,055	1 6
White clover	2	1,434	1 10
Lucerne	1	219	0 10
Sainfoin	5	110	0 6
Burnet	4	259	1 7
Chicory	1	284	0 11
Yarrow	⅛	417	0 9
Total	33⅛	12,764	20 2

Professor Middleton recommends that burnet and sainfoin, which may be purchased mixed, as also lucerne, chicory, and yarrow, should be included in the mixture, as "these plants are either useful in themselves or are indirectly useful in opening up the soil by means of their strong roots; and, further, in the case of burnet and chicory, by keeping the hay crop erect and open, thus allowing light to reach the white clover and young grasses."

Further, Professor Middleton suggests that, as poor clay soils are frequently deficient in phosphates, a dressing of 3 to 4 cwt. of superphosphate per acre should be applied before the seeds are sown, and a dressing of 5 to 7 cwt. of basic slag per acre in the autumn, after the first hay crop has been cut. "Basic slag will greatly encourage the growth of the clovers, and if subsequently the stock grazing the pastures receive oilcakes, the permanent grass will benefit. The above quantity of seed should be enough for clean land in good tilth. On a rough surface increase the rye-grass and red clover to ensure a cover; and to counteract the effects of rye-grass on the other pasture plants, manure liberally about the third or fourth season." [1]

The treatment of permanent pastures on high-lying and rough land is dealt with in vol. i. pp. 340-346.

ENSILAGE.

The practice of Ensilage may be defined as the preservation of green food by the exclusion of air. In a modified sense the system is an ancient one, but in the United Kingdom it was not pursued to any considerable extent prior to 1882.

History of Ensilage.—From time immemorial the storage of grain in underground pits for preservation has been practised in Eastern countries. Pliny speaks approvingly of this method as being adopted, in his time, in Thrace, Cappadocia, Barbary, and Spain. Varro endorsed his opinion of its merits, and asserted that wheat could be thus kept sweet and entire for fifty years, and millet for a century. The main object, especially among nomadic tribes, was to prevent marauders or victorious enemies from obtaining their stores of food.

In later days the practice was adopted—in Spain for example—for commercial reasons, as by its means the surplus in years of plenty and low prices could be kept for disposal in times of scarcity and high prices.

It appears to have been in Germany that the system of ensilage was first applied to the preservation of fodder crops, as distinguished from grain. In an article in the *Transactions of the Highland and Agricultural Society* so far back as 1843, Professor Johnston gave a detailed description of the German system of making "sour hay."

In 1874 Professor Wrightson, in his "Report on the Agriculture of the Austro-Hungarian Empire," published in the *Royal Agricultural Society's Journal*, remarked that "the system of making 'sour hay' is also well worth the attention of English agriculturists. It is done by digging graves or trenches, 4 feet by 6 or 8 feet in depth and breadth, and cramming the green grass or green Indian corn tightly down into them, covering the whole up with a foot of earth. The preservation is complete, and the wetter the fodder goes together the better. . . . This sour hay affords a capital winter fodder, and when cut out with hay spades it is found to be rich brown in colour, and very palatable to stock."

Introduction into Great Britain.—In 1882 the practice of ensilage began in the United Kingdom in real earnest, and in the course of the next few years the progress was rapid. In 1883 the Ensilage Commission—a private but highly influential body, whose labours were endorsed by the Government, and embodied in official Blue-books—sat and collected a mass of invaluable evidence.

[1] *Jour. of the Board of Agric.*, New Series, No. 8, vol. xii. p. 462.

The Agricultural Returns first included ensilage in their survey in 1884, and enumerated 610 silos as being in existence in Great Britain.

Silos.

A silo was originally a pit—the word being derived from the Greek σιρὸς, which, according to Liddell and Scott, is "a pit or hole sunk in the ground for keeping corn in." The word came to us through the Spanish and French, in which languages the *r* was naturally changed to *l*. Soon, in practice, "a pit or hole" was found to be adaptable only to special soils and situations, and a large variety of receptacles for ensilage, both below and above ground, have been constructed, which have widely extended the original term silo.

It would be impossible even to enumerate the different descriptions of silos which have been tried. From the most elaborately designed and expensively constructed buildings to the simplest and cheapest "converted" structure, the variety of methods resorted to has been remarkable. Some idea of their diversity may be gathered from the fact that the cost per ton capacity has ranged from 8s. up to 30s. or 40s., and even 50s.

Silos, Above or Below Ground?—In making a silo, the first question is obviously whether it shall be dug out or erected. Sunk silos were thought in some respects preferable, but the cost of excavation has to be considered. Latterly, where the system is still pursued, silos above-ground have almost entirely superseded sunk silos.

Concrete Silos.—In many cases silos have been formed largely of concrete. On Lord Ashburton's estate a silo with a total capacity of about 96 tons was substantially built of concrete at a cost of £113. It was formed in three compartments, and roofed with corrugated iron.

Silo with Lever-pressure.—A silo erected by Mr C. G. Johnson with special lever-pressure is worthy of mention. It was built of brick, with slated roof. It was 18 feet long, 10 feet wide, and 28 feet high up to the eaves, but 6 feet of this height was left for working the machinery, so that the total capacity, at 50 cubic feet to the ton, would be about 80 tons. But Mr Johnson's silage weighed very much more than usual, as it reached 60 lb. per cubic foot; and at this rate, if the whole space were occupied, fully 100 tons could be put in. The total cost of the silo and apparatus was about £150, of which £65 was for masonry, £40 for pressing apparatus, and the remainder for roof, &c.; but Mr Johnson was his own engineer, and the cost would have been higher had a professional man been employed to superintend the work. Deducting £40 for pressing apparatus, the cost, at the same rate as in other cases, would be about 22s. per ton.

Wooden Silos.—Wooden silos also came into favour when it was discovered that lateral pressure was practically non-existent in making silage.

American and Canadian Silos.—In the United States of America and Canada, most farms which have milch cows as part of their stock are provided with silos. These silos are most generally made of concrete, and are variously shaped, in different parts of the country. They also vary greatly in capacity. In most cases they are built at the end or side of the cow-house. They are generally filled with green maize stalks cut into half-inch lengths, the fodder being conveyed from the cutter to the silo by a mechanical conveyer. For the production of winter milk, cut maize in the shape of silage is to the American or Canadian dairymen what roots are to dairymen in the United Kingdom.

Methods of Pressure.

The methods of obtaining pressure in silos are as varied and numerous as the forms of the silos themselves. Dead weights—earth, stones, bricks, iron, &c. —were the elementary forms, and are still largely used. The labour of putting on and taking off the weight is, however, obviously great, and this led to the introduction of a great variety of mechanical appliances for the purpose.

Stack Ensilage.

Soon after it was discovered in this country that there was practically no lateral pressure in the silo, experiments were tried in the making of silage in stacks. The results were favourable,

and this practice extended rapidly. It was found that there was usually more waste in the stack than in the silo, through exposure of the food material at the sides of the former; but, on the other hand, the saving of the cost of erecting silos was an important consideration.

Sweet and Sour Silage.

"Sweet" and "sour" are arbitrary terms which have perhaps been somewhat abused in the ensilage controversy. Perfect silage—that at which all makers should aim—is neither the one nor the other. But it was found easier to make "sweet" silage in a stack than in a silo, and easier to make "sour" silage in a silo than in a stack. That is to say, in a stack the temperature rises very rapidly, and the difficulty lies often in preventing too great heat. In a silo it may be necessary to wait at intervals for the temperature to rise, and the work of filling has thus to be interrupted.

Making Sweet Silage.—The general practice at the outset in this country was to apply pressure directly the silo was filled, and the product was sour silage. It was discovered that the sourness could be got rid of, at least to a large extent, by deferring the weighting of the mass for two or three days, until the temperature of the silage rose to about 120° or 140° Fahr. The theory was that this temperature, about 120° Fahr., is sufficiently high to kill the bacteria which produce acid fermentation; and if the bacteria be thus killed, and the silo then covered and weighted, the enclosed mass of green fodder will remain sweet, and be practically preserved under the same conditions as fruits, vegetables, or meats are preserved when canned.

In practice the theory was found to be a sound one, but to ensure good sweet silage careful attention has to be given to the temperature during the making process. With the aid of a stack-thermometer, it is easy to ascertain exactly the rise and fall of temperature in either a silo or silage stack.

If a tube 1 inch in diameter be built in a perpendicular position in the centre of the silo, a thermometer attached to a string may be dropped into it at any time and the temperature found. As the building of the contents proceeds, this tube may be pulled up, so as always to have the bottom of it 6 to 10 feet from the surface. After a temperature of 125° to 140° Fahr. has been reached by loose building, a further addition of material to the top will so compress what is 10 feet lower that the temperature will begin to fall. Silage so made will invariably turn out sweet.

Analyses of Sweet and Sour Silage.—As would naturally be expected, the stock prefer the sweet to the sour silage. By analysis it was found that there is little difference in the feeding properties of the two kinds of silage, sweet silage having usually a slight advantage. The following are analyses of samples of sweet and sour silage made by the late Dr A. P. Aitken:—

	Earlypier.		Harcus.	
	Sweet.	Sour.	Sweet.	Sour.
Water	75.09	76.08	69.39	77.77
Solids	24.91	23.92	30.61	22.23
	100.00	100.00	100.00	100.00
Solids (dried at 212° Fahr.)—				
Albumen	6.52	6.33	6.71	6.33
Non-albuminoid nitrogenous matter reckoned as albumen	4.43	3.64	2.02	2.28
Carbohydrates	44.55	46.18	46.05	47.87
Ether extract	6.20	5.95	6.85	6.35
Woody fibre	28.85	25.15	30.20	28.70
Ash	9.45	12.75	8.17	8.47
	100.00	100.00	100.00	100.00

Pressure for Ensilage Stacks.—A good method of applying pressure to ensilage stacks is shown in fig. 578.

Another system of pressure in use is that known as Blunt's patent (fig. 579). It combines the two principles of the

screw and lever, and one main advantage claimed for it is that by its means "continuous pressure" is secured.

Crops for Silage.

There are many kinds of crops which are suitable for making into silage. It is well to bear in mind that the quality of the silage is directly dependent upon the quality of the material from which it is made. This may appear to be a simple truism, but it is by no means unnecessary to insist upon it. In the early days of the system there seemed

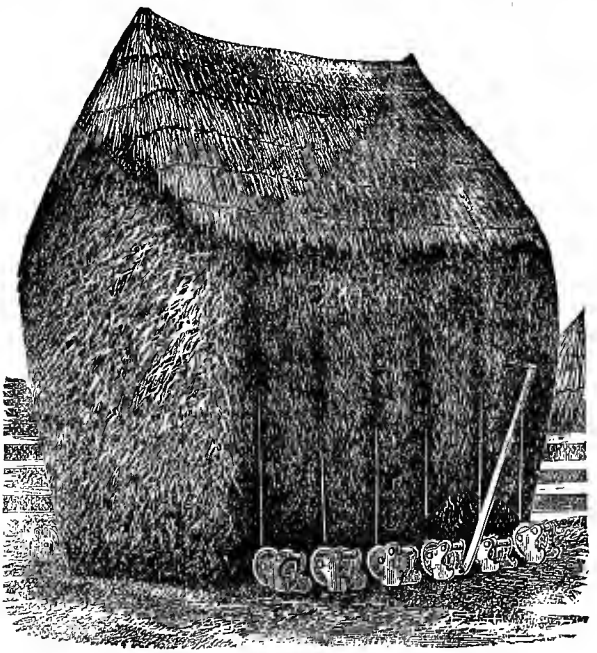


Fig. 578.—*Johnson's ensilage press.*

to be a common idea that silage was silage—so to speak—whatever it might be made from, some people apparently

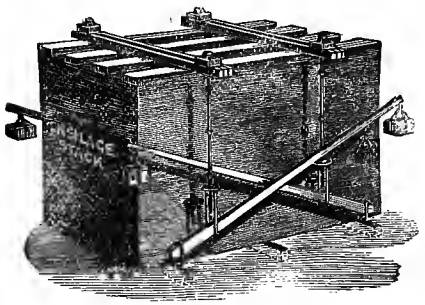


Fig. 579.—*Blunt's ensilage press.*

thinking that coarse, useless grass, or waste substances, might be ensiled and transformed into valuable food. That such materials may be, and are, made into silage with advantage, is no doubt true; but it is essential for those who use them to remember that the process of ensilage does not give them any higher feeding value, other than possibly to make them more palatable or digestible to stock. No formation of food constituents goes on in the silo or stack, and practically that which a farmer puts in, that will he—if the silage be well made—take out. It follows, therefore, that those who wish for valuable silage must make it of a valuable crop.

The crop which has been most used in this country for silage has been meadow grass, but sewage-grown Italian rye-grass, tares, green grain of any kind, clover, lucerne, sainfoin, &c., may each be made into silage. All the grass crops should be put in the silo without any chopping;

if green and succulent, tares, grain, and lucerne may be treated in the same way, but if the stalks of either are the least hard the crop should be run through a straw-cutter and cut into one-inch lengths. If this is not done, air remains in the stalks, and the material does not pack sufficiently firm to exclude air. Such material rarely keeps well, and almost invariably turns out mouldy.

Such soft materials as mangold, turnip, and carrot leaves are not suited for turning into silage. They have too little fibre in them, and in the silo they go into pulp.

Feeding Value of Silage.

From time to time there has been much discussion as to the feeding value of silage. Advocates of the system claim that in numerous experiments which have been carried out the results have in the main favoured silage.

Hay *v.* **Silage.**—Feeding trials conducted by the Royal Agricultural Society of England with hay and silage made from equal areas of the same field finished with a very slight advantage on the side of the silage. Other trials by the same Society with oat-silage as against roots and chaffed straw ended more decidedly in favour of the silage.

Advantages claimed for Ensilage.

Reference has already been made to the English Ensilage Commission, which inquired into the subject in 1883 and prepared a Report, which was published by the Government as a Blue-Book. The general advantages claimed for ensilage are set forth fully and clearly in that Report. The advantages of the system are classified by the Commission under these three heads: "1. In rendering the farmer independent of weather in saving his crops. 2. In increasing the productive capabilities of farms: (*a*) in greater weight of forage saved; (*b*) in greater available variety and rotation of crops; (*c*) in increased facility for storage. 3. In connection with feeding: (*a*) dairy stock; (*b*) breeding stock; (*c*) store stock; (*d*) fattening stock; (*e*) farm-horses." Taking each of these points in order, the Commission remark upon them as follows:—

"1. *Independence of Weather in saving Crops.*—In this respect it has been abundantly proved to us that ensilage is of great economic value. In Scotland, in Ireland, and in the north and west of England, few seasons occur in which more or less difficulty is not experienced in reducing green fodder crops to a sufficiently dry condition for stacking in the ordinary way. This is especially the case with second crops of clover and aftermath. The loss occurring through ineffectual attempts to dry such crops, or through their inferior condition when carried, is often very considerable; and it is obvious that any system which enables a farmer to store these in good condition for future use must be a great saving of expense and anxiety.

"2. *Advantages in increasing the Productive Capabilities of Farms: (a) In greater Weight of Forage saved.*—It is obvious that unless the forage in a weighty condition be of more feeding value per acre than when saved in a less weighty form, there can be no gain to the farmer. It has been contended that the loss of weight in the process of drying is simply loss of water by evaporation, and that by avoiding this nothing is saved. If such were truly the case, dry forage should give the same feeding results per acre as green forage. No practical farmer would contend that it does so, and the difference is especially noticeable in the case of dairy stock. So far as we have been able to ascertain the opinion of competent men on this subject, we estimate the value of green forage well preserved in a silo at somewhat more than one-third, weight for weight, of the value of the same material made into hay under favourable conditions. The very wide difference of value between good and bad silage cannot be too strongly insisted upon. It is found that grass well preserved in a silo, after deduction for loss, will yield approximately five times the weight of the same grass made into hay. We have therefore, say, five tons of silage, which, taken at one-third the value of hay per ton, yields a profit of over 60 per cent as compared with one ton of hay. If we take it at one-fourth, it still leaves a profit of 25 per cent. Any waste that may occur to reduce the weight of nutritious forage, whether by evaporation or by excess of chemical

change, must necessarily affect this calculation, which is based upon the highest degree of perfect preservation so far known to be attainable.

"(*b*) *In Available Variety and Rotation of Crops.*—By the process of ensilage many crops can be preserved which would not otherwise be found profitable if used in the form of green forage. Rye, oats, millet, maize, barley, and even wheat, if cut about the time of attaining their full development, but before the seed begins to harden, have been successfully used as food for cattle through the medium of the silo. Such of these crops as are found to reach the required condition before the middle of June, if cut before that time, will leave the land free for a second sowing, and thus increase its capabilities of annual production, while maintaining the fertility of the soil. Where land is well treated, maize, buckwheat, or, in some parts of England, also turnips, can be sown after green rye or oats are cut and carried, and thus a second crop may be secured for preservation in the silo, or for consumption by sheep on the land.

"(*c*) *In Increased Facility for Storage.*—This advantage has been forcibly impressed upon us. It enables farmers to guard themselves against emergencies, such as frequently arise in our climate through prolonged cold in February, March, and April, causing great scarcity of food for cattle and sheep, where the supply of roots is inadequate.

"3. *Advantages connected with Feeding:* (*a*) *Dairy Stock.*—We have received the strongest evidence of the undoubted advantage of the system for the feeding of dairy stock. The effect of dry winter food given to such stock has always been to reduce in quantity and to deteriorate in quality milk, cream, and butter, as compared with the same products resulting from green summer food. Although the degree of perfection attainable in summer has not been reached, it has been at least much more nearly approached by ensilage than by the use of hay and other dry foods, while at the same time the objections inseparable from the employment of roots for this purpose have been overcome. A sensible improvement in the colour of butter has been especially noticed.

"(*b*) *Breeding Stock.*—Green fodder preserved by ensilage has been successfully employed in feeding sheep and cattle at the time of breeding; and as it has been shown to increase the flow of milk, it will undoubtedly be found useful for this purpose, although the proportion of its admixture with other kinds of food must always require care and judgment.

"(*c*) *Store Stock.*—It forms a complete and wholesome food for store stock.

"(*d*) *Fattening Stock.*—The value of this process for the purpose of forming flesh and fat has not yet perhaps been so widely demonstrated as in the case of dairy produce. At the same time the results attained show that it compares favourably with the use of roots, and, if given in proper proportions with other food, it affords a cheap substitute for the same bulk, which would otherwise be required in some different form. The advantage of its use is most apparent in the degree to which it enables a farmer profitably to consume straw-chaff, rough hay-chaff, and other dry materials, which, without admixture with some kind of moist food, would not be palatable or advantageous to the growth of stock.

"(*e*) *Farm-horses.*—Strong as the evidence has been of the advantage of ensilage for keeping all stock in healthy condition, farm-horses have by no means been excepted. We have received highly satisfactory accounts from several quarters of the health of working teams when given a limited proportion of silage mixed with other food."

In conclusion, the Commissioners state that they endeavoured to discount all exaggerated estimates, as well as to make allowance for a considerable amount of prejudice and incredulity which they met with, and they add: "After summing up the mass of evidence which has reached us, we can without hesitation affirm that it has been abundantly and conclusively proved to our satisfaction that this system of preserving green fodder crops promises great advantages to the practical farmer, and, if carried out with a reasonable amount of care and efficiency, should not only provide him with the means of insuring himself to a great extent against unfavourable seasons, and of materially improving the quantity and quality of his dairy produce,

but should also enable him to increase appreciably the number of live stock that can be profitably kept upon any given acreage, whether of pasture or arable land, and proportionately the amount of manure available to fertilise it."

Ensilage Losing in Favour.

For a number of years after the issue of the Report of the Ensilage Commission the system was largely pursued in different parts of the British Isles. On the whole, the results continued to be fairly satisfactory. Gradually, however, it became apparent that the system had not obtained an extensive permanent footing in this country. Early in the last decade of the nineteenth century the practice of ensilage began to wane, and in the course of a few years it almost altogether disappeared from several districts in which it was for a time pursued. It may now be said that ensilage is practised in this country only to a very limited extent.

It is no doubt the case that the occurrence of better seasons in the matter of weather had something to do with the change of feeling towards ensilage. There are some who still continue the system, and there are many who look upon it as a valuable agent in the hands of the agriculturists of the British Isles, especially in seasons of inclement weather. In view of these considerations, the system seemed still deserving of the notice it has received in this edition of *The Book of the Farm.*

THE POTATO CROP.

The potato crop is one of increasing importance to the farmers of the United Kingdom. It is a costly crop to grow and prepare for the market, and it involves a good deal of risk, but in average seasons it is moderately profitable. Not unfrequently it is the best paying crop on the farm.

Varieties of Potatoes.

The potato belongs to the class and order *Pentandria Monogynia* of Linnæus; the family *Solaneæ* of Jussieu; and to class iii. *Perigynous exogens;* alliance 46, *Solanales;* order 238, *Solanaceæ;* tribe 2, *Curvembyræ;* genus *Solanum* of the natural system of Lindley.—Lindley observes that this family of plants are "natives of most parts of the world without the arctic and antarctic circles, especially within the tropics, in which the mass of the order exists in the form of the genera *Solanum* and *Physalis.* The number of species of the former genus is very great in tropical America."

The *Solanaceæ*, or Nightshades, comprise 900 species, of which we have only five in Britain. The genus *Solanum* has only two British representatives—*Solanum dulcamara*, a pretty climbing shrub, found occasionally in hedges; and *Solanum nigrum*, with a herbaceous stem. Both these plants, like the rest of the tribe, are strongly narcotic. The *Solanum dulcamara*, bitter-sweet, or woody nightshade, has a purple flower and bears red berries; the *Solanum nigrum*, or garden nightshade, bears white flowers and black berries. These plants can be identified botanically only by an examination of the leaves and berries. The active principle in both is an alkaloid, *Solanine*, which is itself a poison, although not very energetic: two grains of the sulphate killed a rabbit in a few hours. According to Liebig, this poisonous alkaloid is formed in and around the shoot of the common potato when it germinates in darkness; but there is no evidence that the potatoes are thereby rendered injurious. Their noxious qualities are probably due to other causes.

Introduction into Europe.—It is asserted that Sir Francis Drake introduced the potato into Europe in 1573, but this is very doubtful, since it has also been ascribed to Sir John Hawkins in 1563: it is, however, certain that Raleigh brought it from Virginia to England in 1586; and it is believed that the Spaniards had established its cultivation in Europe before this time. It was first

cultivated extensively in Belgium in 1590, in Ireland in 1610, and in Lancashire in 1684. Between 1714 and 1724 it was introduced into Swabia, Alsace, and the Palatinate; in 1717 it was brought to Saxony; it was first cultivated in Scotland in 1728; in Switzerland, in the canton of Berne, in 1730; it reached Prussia in 1738, and Tuscany in 1767. It spread slowly in France till Parmentier, in the middle of the eighteenth century, gave it so great an impulse that it was contemplated to give his name to the plant; the famine in 1793 did still more to extend its cultivation.

Distribution of the Potato.—According to Humboldt, the potato is generally cultivated in the Andes, at an elevation from 9800 to 13,000 feet, which is nearly the same elevation to which barley attains, and about 9800 feet higher than wheat. In the Swiss Alps of the canton of Berne the potato reaches, according to Katsoffer, an elevation of 4800 feet.

In the north of Europe the potato is grown farther north than barley, and it is cultivated in the mountainous regions of India.

Varieties in Use.—The varieties of potatoes now in use are very numerous. Several hundreds indeed there are, and every year adds to the number.

The principal kinds planted vary from time to time, new sorts taking the place of older kinds which ultimately degenerate. Great interest is now taken in rearing new varieties, and new sorts of considerable promise are offered to farmers almost every season.

The influences of soil and climate introduce variations in the different sorts, but the multiplicity of varieties is due mainly to the raising of new sorts from the seed. It has been found that an occasional new variety successfully resists disease for a few years, and this, of course, has given a great stimulus to propagation from seed.

Good Potatoes.—A good potato is neither large nor small, but of medium size; of round shape, or elongated spheroid; the skin of rough and netted appearance, and homogeneous; and the eyes neither numerous nor deep-seated. Smooth potatoes are almost always watery and deficient in starch.

Some kinds of potatoes are fit to use when lifted, but other kinds improve with keeping, and are best in spring.

The *intrinsic* value of a potato, as an article of commerce, is estimated by the quantity of starch it yields on analysis; but, as an article of domestic consumption, the *flavour* of the starchy matter is of as great importance as its quantity. Almost every person prefers a mealy potato to a waxy one, and the more mealy the better flavoured it usually is. The mealiness consists of a layer of mucilage immediately under the skin, covering the starch or farina, which is held together by fibres.

Light soil yields a potato more mealy than a strong soil; and a light soil produces a potato of the same variety of better flavour than a clay soil. Thus soil has an influence on the flavour, as well as on culture; and the culture which raises potatoes from soil to which dung had been applied some time before planting, imparts to them a higher flavour than is obtained when the tubers are grown in immediate contact with dung.

Potato Disease.—The fungoid diseases which attack potatoes will be dealt with in connection with other "Fungoid Diseases" of crops, as will also the spraying of potatoes, now so largely resorted to for the checking of disease.

SOIL AND TILLAGE FOR POTATOES.

In most cases the potato crop is grown after a crop of oats, which, in turn, had succeeded pasture. In some districts potatoes come after lea, and this many consider the best place in the rotation for the crop.

Land for Potatoes.—Potatoes thrive best on light dry, friable, or sandy loams. They also do well upon virgin soils and mossy or turfy land, but seldom give good results on strong, tenacious clays, with retentive subsoils.

Tillage for Potatoes.—The stubble land intended for potatoes is ploughed early in the autumn, so that it may have the full benefit of the ameliorating influences of winter. Potato land should be tilled early in spring, and cleaned as well as possible. The time for cleaning land is usually limited in spring, so that the

cleanest portion of the fallow-break should be chosen for the potatoes to occupy.

After cross-ploughing or grubbing, the land is thoroughly harrowed with a double tine along the line of the furrow, and a double tine across it, and any weeds brought to the surface and gathered off. If the land be clean, it is then ready for drilling; if not, it should receive a strip of the grubber in the opposite direction, and again be harrowed, and any weeds gathered off.

The cross-ploughing of potato land in spring is not so extensively practised now as formerly. With deep autumn or winter ploughing little spring stirring suffices, and if the land is clean, and the soil fine and friable, rank harrows may do all that is necessary. Most likely, however, a strip of the grubber will be beneficial; and as grubbing is a speedy operation it need not long delay the planting.

In cultivating land for potatoes, it is important to remember that the roots and tubers should have free scope to ramify in the soil.

MANURING POTATOES.

It is well known that no farm crop is more variable in its yield than the potato crop. In two successive seasons, when the land and the treatment are the same, the one crop may be twice as great as the other. The chief element of success is the weather,—not the weather of the whole season, but the weather at certain critical periods—the favourable distribution of shower and sunshine. In this respect potatoes are far more dependent on weather than are most other farm crops. Whether the season prove such as to favour a big crop or not, the manuring for potatoes must be liberal if the best yield is to be gathered; but in some years the same manuring will give a far greater increase than in others.

Dung for Potatoes.—Farmyard dung is the staple manure for potatoes. Without a certain amount of dung they are seldom grown; and heavier dressings of dung are employed for potatoes than for any of the other ordinary crops of the farm. From 15 to 20 tons per acre are common quantities, and the dressing is often as much as 25 tons or more per acre.

Mechanical influence of Dung on Potatoes.—It is obvious that the potato crop cannot make immediate use of more than a small portion of the plant-food contained in these heavy dressings of dung. Farmyard manure, however, would seem to be far more to the potatoes than a source of nutrition. Its mechanical influence upon the soil has evidently a peculiarly beneficial effect on this crop. It not only opens up the soil and renders it more friable, but by the decay of the organic matter the temperature of the soil is raised, thus surrounding the potato with more kindly conditions than would have existed in the absence of dung. These heating and pulverising influences of dung are undoubtedly of great importance; some, indeed, are inclined to think that a good deal more of the value of dung as a manure lies in these functions or influences than has usually been associated with them.

Typical Dressings.—In the Lothians of Scotland, where potato-growing is a prominent feature in the system of farming, the dressing of dung ranges from 20 to 30 tons per acre—even as much as 35 tons or more per acre being occasionally used for an early crop. In addition to these allowances of dung, from 5 to 10 cwt. of artificial manure is applied, the latter consisting of guano, dissolved bones, superphosphate, and perhaps a little potash, or instead of guano, nitrate of soda or sulphate of ammonia. A dressing of 6 cwt. of artificial manure sometimes used with about 20 tons of dung, consists of 2 cwt. bone meal, 1 cwt. vitriolised bones, 1½ cwt. of mineral superphosphate, 1 cwt. sulphate of potash, and ½ cwt. sulphate of ammonia. On light lands in Ayrshire, where potatoes are successfully grown for early consumption, very heavy manuring is practised. In some cases here as much as 30 tons of dung, and 12 to 15 cwt. of artificial manure, are applied per acre—the artificials consisting of 4 or 5 cwt. of kainit, and 8 or 10 cwt. of a mixture containing from 8 to 10 per cent of ammonia and 20 to 30 per cent of phosphate.

Quickly acting Manures for Potatoes.—For potatoes, manure should be supplied in a readily available form near at hand, as it is a moderately rapid growing, feebly-rooted plant. It is thus

desirable that, however much dung may be applied, a certain quantity of more quickly acting manure should also be given. It may be that the dressing of dung will contain far more nitrogen, phosphoric acid, and potash than the crop of potatoes will require. Experience, however, has clearly shown, notably in the case of the Rothamsted experiments, that only a very small portion of the plant food in the dung can be utilised by the first crop of potatoes. Thus, while the heavy dressing of dung is beneficial, partly as a source of manure and partly on account of its mechanical influence on the soil, it is necessary to apply phosphates, nitrogen, and potash in forms in which they will be immediately available to the crop. For this purpose, mineral superphosphate, guano, sulphate of ammonia or nitrate of soda, and kainit, are most largely used. Some prefer sulphate or muriate of potash because of the excess of salt in kainit.

For early potatoes, which grow rapidly and are only a short time in the ground, quickly acting manures are most suitable.

Dr Aitken on Manuring Potatoes.

With special reference to the experiments conducted under the auspices of the Highland and Agricultural Society, the late Dr A. P. Aitken wrote as follows as to the manuring of potatoes:—

"The potato is a feeble rooter, and requires its manurial food to be closely within reach. In order that the tubers may be able to expand, the soil about them must be loose. Manures which keep the roots free are therefore very appropriate. There is nothing so suitable as dung for that purpose, but any very bulky manure is also good, and especially if it has a large proportion of organic matter to keep the soil warm and make a soft compressible seed-bed.

Form of Manures for Potatoes.—"The potato is not well adapted for utilising insoluble materials, and therefore any artificial manures applied with the dung should be of a soluble, or, at least, not very insoluble kind. Superphosphate is better than ground mineral phosphates or bone meal; and even dissolved bones is rather a slow manure for this crop.

Nitrogen for Potatoes.—"The most important ingredient of a potato manure is nitrogen, and the most of it should, as has been said, be of a soluble quick-acting kind. Insoluble nitrogenous matters do not come into activity quickly enough for the wants of the crop. When dung is used, there is no better way of increasing the nitrogenous manure than by giving some nitrate of soda or sulphate of ammonia along with the dung.

Potash for Potatoes.—"As regards potash the wants of the potato crop are peculiar. The potato plant takes away a great deal of potash; and fields on which potatoes are frequently grown very soon become exhausted of potash. This must be made good, for the potato is very dependent on potash manures. Where much dung is used there is little need of applying extra potash manure, seeing that dung is so rich in potash; yet much of the potash in dung is not very readily available, and an addition of potash salts is therefore to be recommended.

Too much Potash Injurious.—"Where no dung is used, potash forms an exceedingly important ingredient. The limit of potash manure required for potatoes is nevertheless very soon reached; and no good but rather harm is done by overdoing the application of potash.

"It is a common practice to apply very large doses of light manures to the potato crop. Much extravagance may occur in that way, and sometimes more harm than good result. It is important in such cases that the manure should not be placed in direct contact with the sets. It should rather be applied some time before planting, and should be well incorporated with the upper layer of the soil as a general fertilising application.

Proportion of Manurial Ingredients.—"When no dung is used, the proportion of the manurial ingredients in a well-balanced potato manure will be just about equal parts potash, ammonia, and phosphoric acid. When applied along with dung the potash may be diminished by half, and the nitrogen slightly increased." On the most of soils good results have been obtained from the following mixture: 1 cwt. sulphate of ammonia, 1½ cwt. sulphate of potash, and 2 to 4 cwt. superphosphate, given along with about 10 tons of dung, the

dung being applied in the drills at the time of planting.

Rothamsted Experiments with Potatoes.

An interesting series of experiments upon the manuring of potatoes was conducted at Rothamsted. The results were fully explained by Sir Henry Gilbert in his lectures at Oxford and Cirencester, and several of them are of considerable practical value to farmers.

Farmyard manure was tried by itself and in conjunction with nitrogenous, phosphatic, and potassic manures. The potatoes were grown on the same land every year, and on this account the results cannot be unreservedly applied to potato culture under ordinary rotation farming. Still some lessons of importance may be learned.

Farmyard Dung.—This was applied at the rate of 14 tons per acre every year, and the average yield for six years was 5¼ tons per acre—just over 3 tons more than the plot which had no manure of any kind in those six years.

Dung and Superphosphate.—The addition of 3½ cwt. superphosphate of lime to the dung had very little influence on the crop. The yield rose to 5 tons 12 cwt., or an increase of 7 cwt. over the dung alone.

Dung, Superphosphate, and Nitrate of Soda.—But when the dung and superphosphate were supplemented by some nitrate of soda, supplying 86 lb. of nitrogen per acre, a marked difference upon the crop became apparent. The produce rose to 7 tons 2 cwt.—an increase of 1½ ton, due to the 86 lb. of rapidly acting nitrogen.

Artificial Manures.—Artificial manures were also tried by themselves, separately, and in different combinations.

Superphosphate of lime (3½ cwt. per acre) applied alone gave an average of 3 tons 13⅜ cwt. for twelve years—nearly 2 tons 6 cwt. more than the no-manure plot.

Mixed mineral manure (consisting of 3½ cwt. per acre of superphosphate, 300 lb. sulphate of potash, 100 lb. sulphate of soda, and 100 lb. sulphate of magnesia) gave only 2 cwt. per acre more than the superphosphate alone.

Salts of ammonia (459 lb.) alone gave a poor result—only 2 tons 5¾ cwt. per acre, or 6 cwt. more than the unmanured plot.

Nitrate of soda (550 lb.) alone did little better. It exceeded the salts of ammonia by 7 cwt. per acre.

Nitrogenous and mineral manures mixed produced very different results. Applied together to the same plot they raised the produce to an average of over 6½ tons—6 tons 14½ cwt. for salts of ammonia and mixed mineral manure, and 6 tons 13 cwt. for nitrate of soda and mixed mineral manure.

Conclusions.—In contrasting these experiments with various kinds and dressings of manure, some noteworthy results are observed. As to *artificial manures* it is shown (1) that the exhaustion of phosphoric acid by the potatoes was greater than that of potash; (2) that in the continuous growth of potatoes here it was the available supply of mineral constituents within the root-range of the plant, more than that of nitrogen, which became deficient—hence the greater produce from mineral manures alone than from nitrogenous manures alone; (3) that it is only when all the essential elements of manure are present in sufficient quantity that the full benefit of any kind of dressing can be derived; and (4), that when thus applied together in a well-balanced dressing, artificial (nitrogenous and mineral) manures produced a crop which for twelve successive years exceeded the average yield of the United Kingdom—decidedly greater indeed than the yield from farmyard manure alone, and only about 8 cwt. per acre behind the produce from a combined dressing of dung, superphosphate, and nitrate of soda.

The efficacy of well-proportioned artificial manures for potatoes thus demonstrated at Rothamsted is a consideration of great importance to farmers. Equally valuable to the practical farmer is the unquestionable conclusion that, in efficient and profitable manuring, an essential condition is that the dressing shall be properly balanced—that is, contain all the necessary elements of plant-food in due proportion.

Slow Exhaustion of Dung.—In the Rothamsted experiments with potatoes some interesting information has been brought out as to the behaviour of farm-

yard manure in the soil. The most striking point in these results is the slow action of the dung, particularly of the nitrogen it contained. The dressing of dung applied annually to the potato crop contained, per acre, about 200 lb. of nitrogen—besides, of course, an abundance of mineral matters, &c.; yet from 86 lb. of nitrogen, supplied in the form of nitrate of soda or salts of ammonia, along with an artificial mixture of mineral manures, the average produce was considerably greater than from the dung. Thus it is observed that, while the dung supplied far more nitrogen than the crop required, it did not contain enough in such a readily available condition as could be at once seized by the crop.

Further striking evidence of the slow action of nitrogen in dung was furnished by the fact that by supplementing the dung with some quickly acting nitrogen —86 lb. of nitrogen per acre in nitrate of soda—the produce of the tubers was increased by over 1½ ton per acre.

Residue of Dung.—Then as to the residue of dung, the results showed that it acted very slowly. Of the nitrogen supplied in the annual dressing of dung only about 6.4 per cent had been recovered in the crop of potatoes in the first six years. In the succeeding six years potatoes were grown every year on the same plot without any further application of dung or other manure, and in that time only 5.2 per cent of the unrecovered nitrogen was taken up in the crop. Thus in twelve years only 11.6 per cent of the nitrogen supplied in the dung during the first six years had been recovered in the crop.

Sir Henry Gilbert on Dung for Potatoes.—Referring to this point in his Cirencester lectures, Sir Henry Gilbert said: "In the case of other crops it has been found that only a small proportion of the nitrogen of farmyard manure was taken up in the year of application. But these results seem to indicate that the potato is able to avail itself of a less proportion of the nitrogen of the manure than any other farm crop. Yet in ordinary practice farmyard manure is not only largely relied on for potatoes, but is often applied in larger quantity for them than for any other crop. It is probable that, independently of its liberal supply of all necessary constituents, its beneficial effects are in a considerable degree due to its influence on the mechanical condition of the soil, rendering it more porous and easily permeable to the surface-roots, upon the development of which the success of the crop so much depends. Then, again, something may be due to an increased temperature of the surface-soil, engendered by the decomposition of so large an amount of organic matter within it; whilst the carbonic acid evolved in the decomposition will, with the aid of moisture, serve to render the mineral resources of the soil more soluble."

In considering these results obtained at Rothamsted it should, of course, be borne in mind that the system of cropping pursued on the experimental plots there—the same crop on the same plot every year—differs greatly from that followed in ordinary farming. In all probability, with the more thorough and varied tillage, and the cropping with plants of different depth of roots and different powers of assimilating food which obtain in ordinary rotation farming, the residue of dung would be more speedily recovered by crops than was the case at Rothamsted. Still it can hardly be gainsaid, that the Rothamsted experiments have proved that the beneficial influence of dung upon potatoes is due in a larger measure to its mechanical effect, and in a less degree to it as a source of plant-food, than was before generally believed.

A Practical Lesson.—The chief lesson which the practical farmer is to draw from these conclusions, as to the action of dung, is that, while a large dressing of dung may with advantage be applied for potatoes, it must not be relied upon as the sole source of plant-food for the crop—that the dung must be supplemented with a substantial allowance of quick-acting nitrogenous manure, such as nitrate of soda, and with a smaller application of phosphates and potash.

Potash for Potatoes.—The undoubted value of potash for potatoes is not very clearly shown in the Rothamsted experiments. In soils deficient in available potash the application of about 2 or 3 cwt. of kainit per acre, or, better, of 1 cwt. of sulphate of potash, will be found to have quite a marked effect on the produce. Good results have been

obtained from kainit when sown as a top-dressing just before the drills of potatoes are earthed up for the first time, especially when rain happened to fall soon after, thus carrying down the potash to the roots of the crop, which is then ready to absorb it. Mr John Speir says he prefers to sow the kainit on the ploughed land in autumn or early winter, which indeed is generally believed to be the best plan.

General Observations on Manuring Potatoes.

In some general notes prepared for this work on the Manuring of Potatoes Dr Bernard Dyer says :—

"While dung should be used with fair liberality, excessive dressings should be avoided. Dung moderately, rather for the sake of mechanical texture and warmth than with the view of fully nourishing the crop. Nourish the crop by adding artificials. Sour or peaty soils should be occasionally well limed. Potash should always be used, unless experience has proved it locally useless. It is best to sow 1 cwt. sulphate of potash per acre in winter or early spring. Failing earlier application, let 1 cwt. sulphate of potash be mixed with the phosphatic manure. On soils containing a fair quantity of lime 3 to 6 cwt. per acre of superphosphate or dissolved bones should be given ; on soils poor in lime a like quantity of phosphatic Peruvian guano, or half as much again of basic slag, fine bone meal, or 'basic superphosphate' — well mixed with the soil. For early potatoes nitrogen should be given, either as sulphate of ammonia or nitrate of soda (or both), or dissolved Peruvian guano. For late yielding varieties, planted early, a few cwt. of rape dust or fish guano may supply part of the nitrogen. Sulphate of ammonia must not be mixed with slag. If slag is used, nitrate is more appropriate. With all other forms of phosphate 1 cwt. to 2 cwt. sulphate of ammonia (per acre) may be mixed. This will only be if sufficient nitrogen in dung has been used. If no dung has been used, one to two later dressings should be given of 1 cwt. each time of nitrate of soda or sulphate of ammonia. The former commends itself for top-dressing, except in wet districts. The nitrogenous manure must be given discreetly. In some seasons more is wanted than in others, and the need is best gauged by watching the haulm. Clearly, if the total application is to be controlled, this can only be done by withholding part of it. Hence only 1 or 2 cwt. of sulphate or nitrate (according to soil and locality) should be sown at planting time—the rest being given at intervals as required in top-dressings. In recent experiments 4 cwt. of nitrate per acre, used with phosphates and potash, was found to be a remunerative dressing, even when 12½ tons of stable manure were used. When no dung is used, or in some seasons with dung, as much as 6 cwt. of nitrate per acre has been used with remunerative results."

College Trials in Manuring Potatoes.

A large number of trials in the manuring of potatoes have been conducted in connection with the leading Colleges of Agriculture in this country. As a rule, in these trials a dressing of 10 tons of farmyard manure has done better than twice that quantity, the increase from the larger quantity not being sufficient to cover the extra cost, while the tendency to disease was greater, and the quality and keeping properties of the tubers usually inferior with the heavier dressing of dung. In most cases, the most profitable dressing of artificial manures to accompany dung was found to be a mixture of about 1 cwt. sulphate of ammonia, 2 cwt. superphosphate, and 1 cwt. sulphate of potash per acre. This, or some other similar mixture, along with 10 tons of dung, usually gave a moderately profitable return. The increased yield from any substantial increase in the quantity of artificial manure was usually too small to be profitable. In some cases where no dung was applied good crops were got from artificial manure alone, a dressing of double the quantity mentioned above. Some of the College trials indicated that large allowances of dung, nitrates, and ammonia-salts tended to lower, and phosphates and potash to improve, quality in potatoes.

Application of Manure for Potatoes.

Autumn Dunging.—If the land is strong and a supply of dung happen to be then on hand (which, however, is not

often the case), it is considered a good plan to spread the dung for potatoes on the stubble just before ploughing in the end of autumn or early in winter. This, no doubt, tends to the better preparation of strong land for potatoes; and the carting and spreading of the dung in autumn or winter lightens the pressure of work in spring. One great hindrance to this system is the fact that a sufficient supply of dung is not usually available in the autumn or beginning of winter. Where summer-house feeding is practised, there is generally an ample supply of dung in good time for this purpose; and these two systems, which, in suitable circumstances, are both to be commended, fit well into each other. On dry soils and in dry seasons dunging before ploughing usually gives the best results. In the opposite conditions spring dunging will be found to excel.

Spring Tillage with Autumn Dunging.—When the potato land has been dunged and deeply ploughed in autumn or winter, the spring tillage is simple and soon finished. If the land is clean no further ploughing may be necessary. A single or double stripe with the grubber and moderate harrowing will most likely suffice, and then shallow drills are opened from 28 to 30 inches wide. The seed is planted in these drills with from 10 to 14 inches between the sets, and an allowance of artificial manure is sown, and the drills are closed by splitting each ridgelet in two with the drill plough, such as that made by Newlands, shown in fig. 580.

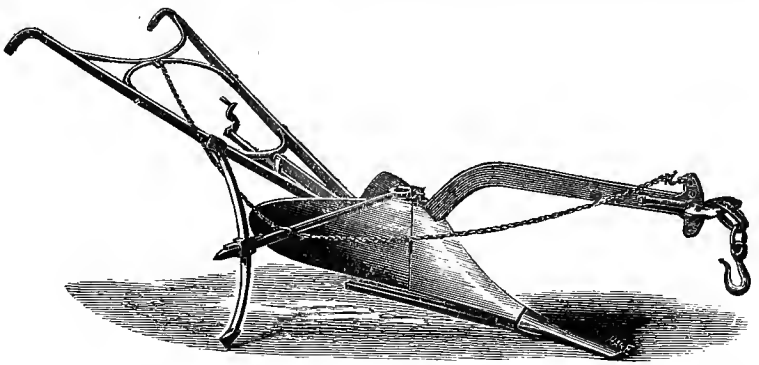


Fig. 580.—*Scottish drill-plough.*

Spring Dunging.—A system largely followed is to apply both the dung and the artificial manure in the drills at the time of planting in spring. If the land is clean and not too rough, a small amount of spring tillage will suffice. When they have to hold dung, as well as the seed and artificial manure, the drills have to be a little deeper than is necessary with previous dunging on the surface.

Carting Dung for Potatoes.—The more expeditious plan is to have the dung carted in a heap on the field before the rush of spring work sets in. In this case the carting of the dung into the drills is speedy work. But it is very often found that better crops of potatoes are obtained from dung carted right from the cattle-court to the drills than from exactly similar dung which had some time before been carted into a heap on the field. Where the lessening of spring work is of special importance, as in late districts, with their long winter and short growing season, it will perhaps still be best to pursue the practice of carting the dung to heaps on the field in winter. In cases, however, where there is no such excessive rush of spring work, and where the potato field is within easy distance of the homestead, the dung had better be left in the courts till required for the drills in spring, or until it is to be spread upon the land in one form or another.

Filling Dung.—To avoid delay in the field, and keep the horses as active as possible, one or two men may be employed at the dung-heap in assisting the drivers of the carts in throwing the dung into the carts, which is done with ordinary

four-pronged steel graips. The movements of the carts are so arranged that only one, or at most two carts are at the dung-heap getting filled at one time.

Distributing Dung from Carts.—The dung is thrown from the cart into the drill in graipfuls as the horses move on at a moderate pace. The quantity of dung intended to be given to the land is evenly apportioned by the farmer or overseer, fixing the length of drill which loads of certain size should cover, and seeing that the man throws out the dung in uniform graipfuls at regular distances. Intelligent horsemen very quickly become expert at this practice, which is far more expeditious and satisfactory than the antiquated method of dragging the dung out of the cart into heaps in the drills.

Three ordinary drills are just about the width of a farm-cart. The dung is often thrown into the drill in which the horse is walking, and one wheel of the second cart thus runs over the dung thrown out from the first cart. This packing of the dung by the cart-wheel should be avoided by throwing the dung, not into the centre drill, but into the drill on the side of the cart next to where the dunging was begun.

Spreading Dung.—The spreading of the graipfuls of dung in the drills is done by men, lads, and women. On many farms this work is now done by mechanical means. An excellent machine for spreading dung in drills is shown in fig. 344 (vol. i. p. 513).

In England women are rarely seen at this work, and in Scotland also the custom of employing them at it is by some strongly condemned as unbefitting modern civilisation. Certainly much less female labour is now engaged in outdoor farm-work than in former times, and the tendency is still towards diminution.

A long-shafted steel fork or graip, with three or four prongs, is best suited for spreading dung. It is very important that the dung should be finely broken and evenly spread in the drill. Lumps of dung should be thoroughly broken, and rolls of straw or other litter undone, so that the dung may not only be evenly distributed over the land, but be so exposed to the surrounding soil as that it may speedily and regularly decompose.

Four or five workers will, in average circumstances, spread as fast as one drill-plough can cover in.

Sowing Artificial Manure.—Whatever artificial manure is to be given at the time of planting is sown broadcast by hand or machine along the drills, after the dung is spread, and either before or after the seed is planted. It is considered preferable to sow the artificial manure before the planting of the seed, so that the manure may not lodge in the "eyes" of the seed. A man sowing with two hands will sow as fast as three drill-ploughs can cover in. Machines to sow two or more drills at a time are now in use on many farms.

PLANTING POTATOES.

The planting of potatoes demands attention early in spring.

Potato-seed.—While the land is being prepared for the potatoes—and it will not be possible to prepare it continuously, as the sowing of grain has to be attended to—the *potato-seed* should be prepared by the field-workers. When preparing potato-seed a great saving of time will be effected if the seconds (*i.e.*, after the ware has been taken out) are dressed over 1¼-inch riddle, and then over 1¾-inch riddle. The tubers above the 1¾ inch should be taken to an outhouse and cut, while the smaller ones can be covered up again and planted whole. In selecting tubers to cut into sets, the middle-sized, that have not sprouted at all, or have merely sprouted buds, will be found the soundest; and wherever the least softness is felt, or rottenness seen, or any suspicion as regards colour or other peculiarity is indicated, the tuber should be entirely rejected, and not even its firm portion be used for seed. The very small potatoes should be picked out and put aside to boil for poultry and pigs.

Potatoes intended for seed should always be turned in the pits between February and March, in order to prevent sprouting.

Potatoes are planted whole or cut into parts or *sets*. Large whole potatoes should not, as a rule, be planted, as it is a waste of seed. Some kinds of potatoes, however, such as Magnum Bonum, are best planted whole. With the Magnum Bonum, growth begins so late in the

season that at cutting time it is impossible to say whether or not any eye will grow. They have few "eyes," which are nearly all at one end, and when cut the part containing the eye is thin. Very small sets, or very small whole potatoes, should not be used as seed, as they are liable to produce a light crop of puny tubers. Moderately small tubers, if they have not too many eyes, make good seed.

The usual practice is to cut a middle-sized potato into two or three sets, according to the number of eyes it contains. It is well to leave two eyes in each set, lest one of them may have lost its vitality. The sets should be cut with a sharp knife. When fresh, the tubers cut crisp, and exude a good deal of moisture, which soon evaporates, and leaves the incised parts dry.

A common practice was to heap the cut sets in a corner of the barn until they were planted. Had they been exposed previously to drought they might remain uninjured, but if heaped immediately on being cut, in a moist state, they will probably *heat*, and heated potatoes, whether whole or cut, rarely vegetate. Much of the injudicious treatment which sets of potatoes receive arises from want of room to spread them out thin. The straw-barn is most generally used, but in many cases it cannot be spared, as the cattle-man and ploughman must have daily access to it. The corn-barn may be occupied with grain. The implement-house has too little room, on account of the many small articles which it contains. The only alternative is an outhouse; a large one should be in every steading.

A considerable quantity of seed should be prepared before planting is begun, and the rest can be made ready when the horses are engaged with the barley or oat seed, or during any broken weather. A considerable quantity of seed can usually be stored about the steading for cutting in wet or stormy weather, while the rest can generally be prepared at the pit-side.

Preserving Sets.—When cut indoors the sets should be spread out thin and dusted with lime. This forms a crust on the incised surface, and prevents the sap from exuding. Potatoes are best cut a day or two before planting, as they keep longer fresh in the ground when there is a crust on the incised surface of the set.

Quantity of Seed per Acre.—The sets required to plant an acre of land vary very much according to size of sets and kinds of potatoes. From 10 cwt. to 15 cwt. of most of the late varieties of potatoes will be sufficient to plant an acre, but many use up to 20 cwt.

Since disease became prevalent among potatoes in all soils and situations, numerous expedients have been devised to prepare the seed, with the view of warding off disease, but without much practical effect.

Potatoes not required for seed, firm and of good size, whether intended for sale or for use in the farmhouse, should remain in the outhouse until disposed of or used, kept in the dark, with access to air, and examined as to soundness when the sprouts, if any, are taken off.

Planting on the Flat.—In many parts of England, where the climate is dry, potatoes are grown extensively on the flat. There autumn or winter dunging is often practised, and by grubbing, harrowing, and ploughing, the land is prepared for the seed in spring. As already stated, the seed in this case is dropped into every third furrow, the seeds being from 9 to 14 inches apart in the furrow. The spaces between the rows of potatoes are hoed by horse and hand hoes just as in the case of drills, and when the plants are well grown they are earthed up by passing a double mould plough between the rows, thus forming ordinary drills.

The Drill System.—But the growing of potatoes in drills is far better than planting on the flat. The drill system is all-prevailing in Scotland (except in some parts of the Highlands and Western Islands) and the northern counties of England, while it greatly predominates in Ireland, except on small holdings where the "lazy-bed" method is still pursued extensively.

Single *v.* Drill Plough.—Mr Speir, Newton Farm, Glasgow, says: "On any land, fine or firm, where one or more ploughs can be kept in constant work, a single mould-board plough with a specially narrow mould-board on, makes *much better* work and is easier held than the double one. With it the soil is lifted and turned right over on the dung and sets—not *shoved* over as with the other. Here no double mould-boards are used at

planting time." It is important that the double mould plough should be formed so as to turn over rather than press the soil outwards. On "cloody" soil the single plough does the better work. The double plough is apt to *enclose* the clods, whereas with the single plough they roll over the crest into the bottom of the next drill and get crushed.

Upon a large farm, where a considerable area is devoted to potatoes, the operations of opening drills, carting dung, spreading dung, planting seed, sowing artificial manure, and closing in drills, all proceed simultaneously. There is no more active scene upon a farm in the course of the whole year than this; and few operations afford greater opportunities for the exercise of skill and forethought in arranging and controlling farm labour.

Planting the Seed.—The spreaders of dung are followed immediately by a similar force planting the seed. Women make the best planters. Five or six planters with the seed regularly supplied to them will plant as fast as the four or five workers will spread the dung; and this force of spreaders and planters, with one man to sow the artificial manure, will keep one drill-plough at full work in

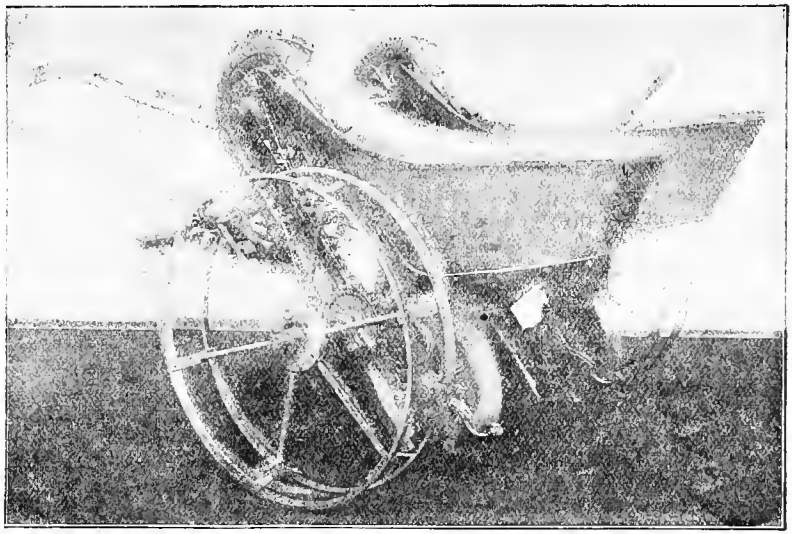


Fig. 581.—*Potato-planter.*

covering in. It is perhaps better that each planter carry her own sets, as a relief to the stooping posture is thus obtained, and each planter should have a separate drill, otherwise parts may be missed. The sets are dropped into the drill upon the top of the dung, at from 9 to 14 inches apart.

Potato-planting Machines.— Machines have been invented for planting potatoes, and some of them do excellent work. Richmond's ingenious potato-planter is shown in fig. 581.

Conveying Seed to the Planters.— The sets are shovelled either into sacks like corn, or into the body of close carts, and placed, in most cases, on one or both head-ridges or middle of the field, according to the length of the ridges. When the drills are short, the most convenient way to get at the sets is from a cart; but when drills are long, sacks are best placed along the centre of the field. A still better plan, if a horse can be spared, is for a boy to drive the potatoes alongside the planters. The cart can go in the drills that are covered, and the boy will carry the sets to the workers.

In some cases a small round willow basket, with a bow-handle, fig. 582, is provided for each person who plants the sets. Others prefer aprons of stout sacking. As a considerable number of hands are required, boys and girls may

be employed beyond the ordinary field-workers. The frying-pan shovel, fig. 342 (vol. i. p. 512), with its sharp point, is a convenient instrument for taking the sets out of the cart into the baskets.

Covering in.—The drill-plough should at once follow the planters, as both dung and potatoes suffer by being exposed to

Fig. 582.—*Potato hand-basket.*

the sun. The drills are split in the same way as they are set up—that is, the plough splits the drill, throwing one-half of the land on one row of sets and the other half on the other, both of the drills being completely covered in two rounds of the plough. The whole of the drills dunged and planted should be covered every day—the man who has been opening helping the one who is covering, after he has opened enough to serve for the day, with a few for a start next morning.

Where there is only one drill-plough, it is employed alternatively in opening and covering in, or opens one way and covers the other. Or the single board plough is used as described on page 304.

Complete Planting as it proceeds.—It is undesirable to open many more drills than can be planted and covered in before nightfall, lest inclement weather should set in, and so render the opened drills too stale before the planting can be resumed. The work of planting is done most satisfactorily where, as far as it goes, it is begun and completed in the same day.

Danger of leaving Dung and Seed uncovered.—Most farmers are specially careful as to the completion of the work of potato-planting as it goes on. In many cases it is insisted that, even at loosing from the forenoon yoking, every drill should be covered in, although the plough-man should work a little longer than the rest of the work-people; for which detention he would delay as long in yoking in the afternoon. In dry hot weather he should make it a point to cover in the drills at the end of the forenoon yoking in a complete manner, as dung soon becomes scorched by the mid-day sun, and in that state is not in good condition—not on account of evaporation of valuable materials, as what would thus be lost would be chiefly water, but because dry dung does not incorporate with the soil for a long time, and still longer when the soil is also rendered dry. If all the ploughs cannot cover in the drills at the hour of stopping at night, give up dunging the land and planting the sets a little sooner, rather than run the risk of leaving any dung and sets uncovered.

An Ayrshire Practice in Potato Planting.—On the earliest farms along the coast of Ayrshire, principally around Girvan, Maybole, and Ayr, where the area of potatoes grown is excessively large in proportion to the size of the farms, a different class of plough is used from that which is commonly met with throughout the country. There the area planted is so great in proportion to the power at the command of the farmer, that a speedier method must be adopted than that in general use. The plough (one of which, made by T. Hunter, Maybole, is shown in fig. 583) has very much the appearance of an ordinary 3-horse grubber, at least so far as the frame is concerned, while it has also two similar side-wheels, a fore-wheel, and lifting lever.

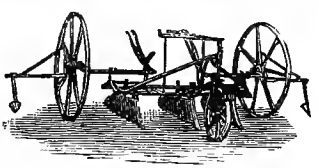


Fig. 583.—*Triple drill-plough.*

Instead, however, of from five to seven tines, it has only three, all set abreast, each tine being in fact a double mould-board plough hung from the frame. The mould-boards are a little less in size than those in use in the ordinary mould-board plough, but otherwise they are the same. By this plough, with three horses, three drills are opened or covered at one passage of the plough. For its proper work-

ing the land must of necessity be well prepared beforehand, and any farmyard manure used has generally been ploughed in some time previously. This plough, indeed, is not well suited for covering in dung.

In this district, where much of the best potato-land is very sandy, a peculiar class of double mould-board plough is also used to earth up the potatoes. In it the mould-boards are solid and continuous from the sole of the plough to the top of the drill, so that in working in dry weather the whole weight of the plough is exerted in pressing the sandy earth on the side of the drill, and in the driest weather slipping down rarely happens. The same class of plough is in use on the early potato-lands of Cheshire, from which district the Ayrshire men adopted it.

Width of Potato-drills.—Abundance of air is of great importance to the potato plant. Where the earlier varieties are grown drills are usually not more than from 26 to 27 inches wide, but for the main crop varieties the most general width of drill is from 28 to 30 inches.

Depth of Sets and Distance apart.—The distance between the sets in the drill varies from 9 to 14 inches, according to the width of the drill, the variety of potato, whether the stems are tall, medium, or short, and the character and condition of the soil and climate, whether likely to favour a heavy or light yield, and the size of the sets. In light soils sets are usually placed about 6 inches under the surface, and in heavy soils slightly less.

Time for Planting Potatoes.—The time for planting potatoes varies with different districts and sorts of potatoes. Early sorts are planted in February and March, and late varieties in April, or in late cold districts in May.

Experiments with Late Planting.—It has been suggested that in certain circumstances potato-planting might be more remunerative if the tubers were not planted until June. To throw light on this point Mr John Speir, Newton Farm, Glasgow, conducted experiments with plantings on different dates in June and July. Early varieties were planted—whole seed which had been strongly sprouted before being set. Farmyard dung alone was used. In the first year the planting on June 30 gave about one-third more produce than the planting ten days later. The July plantings were still more unsuccessful in the second year, but in both years the June plantings gave satisfactory results. In the second year three plantings gave the following results:—

Planted.	Produce.
June 10	7 tons per acre.
" 20	5½ "
" 29	4 "

Mr Speir is quite convinced that the system is capable of great expansion, more particularly on market-garden farms or in late districts. But he adds, that to be attended with any measure of success at all, *the seed must be sprouted, and the sprouts must never have been broken off, but be the first ones which come.*

Culture after Planting.—Potatoes require a considerable amount of horse-work both before and after brairding. As soon as convenient after planting, the drills should be harrowed down either with a set of light zigzag harrows or chain-harrows, or, better still, with a saddle-drill harrow, such as is illustrated in fig. 434 (vol. ii. p. 152). Immediately after, the drills are again set up with the double-moulded plough. When the plants are well sprung, but before they are too far advanced, the drills should be again harrowed down. This makes a fine surface for the young plants, and helps to keep down weeds. A very suitable implement to crush clods on strong land is a fluted roller to embrace two drills, such as that made by T. Hunter & Sons, fig. 584.

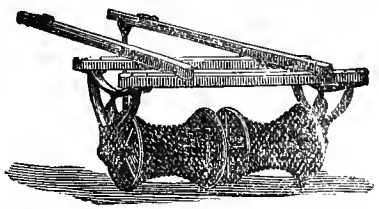


Fig. 584.—*Drill roller.*

This crushes the clods, and leaves the drill in good condition for being harrowed by the saddle-harrows.

Hand-hoeing.—The drills are then hand-hoed, loosening the soil around

the young plants and removing weeds. The hollows of the drills are stirred with the drill-harrow or horse-hoe, and then the drills are set up with the double mould plough. Unless weeds are so abundant and strong as to necessitate another hoeing, no further tillage may be required.

Planting Potatoes in Autumn.

Amongst the expedients suggested for evading the potato disease was planting the sets in autumn. The plan, however, has been only occasionally tried, and even where the circumstances were favourable the success has been very partial.

Autumn Planting unsuitable. — Planting potatoes in autumn cannot be practised everywhere nor extensively anywhere. Potatoes are not only a green but a fallow or cleaning crop, and a green crop being taken after a crop of corn, the stubble of the corn crop is not in a fit state to receive manure before undergoing the process of cleansing by the plough, the harrow, and the grubber, as the land for a fallow crop ought to be; and, in Scotland, too short time intervenes between the harvesting of the corn crops and bad weather in winter to permit the land to be sufficiently cleaned. Hence very few cases occur in which the stubble can be manured in October for potatoes, which occupy so important a position as a green crop. This is perhaps to be regretted, for in the majority of cases where autumn planting was tried it seemed to check the disease.

Method of Autumn Planting. — Potato-planting in autumn is the same as in spring; but there will not be time to stir the land as much. The stubble should be cross-ploughed or grubbed to a considerable depth. Harrowing with a double tine brings up any weeds there are, and these should be gathered off. If the land is first cross-ploughed, the grubber may follow, to cut the furrows in pieces, if there be time for that efficient operation; but if not, the land should be drilled up in the double way, in preparation for the dung.

The after operations are the same as in spring.

Seed for Autumn Planting.—Many think it advisable to use whole potatoes for seed instead of cut sets in autumn. Small potatoes answer well, and save time in cutting. The whole potatoes should be planted in the drill at from 10 to 12 inches asunder.

The Boxing System of preparing Potato-sets.

Mr John Speir, Newton Farm, Glasgow, thus describes the system of preparing the potato-sets in boxes:—

This system was introduced for the purpose of maturing the potato crop sooner than could be attained by the ordinary manner of planting. It is said to have been first introduced in Jersey, where it is extensively practised. Along the whole of the Firth of Clyde it is more or less in use on all the earlier farms, and more particularly in the neighbourhood of Girvan it has been carried to such an extent that several farmers there have upwards of a hundred acres of potatoes all planted from boxes.

Boxes.—The boxes may be of any convenient size or shape, provided they are not too deep, the size in most common use being about 2 feet long, 18 inches broad, and from 3 to 4 inches deep. Each box generally holds from 3 to 4 stones of potatoes, the former being about the average. The boxes are made of ½-inch deal, and have pins 1 inch square and 6 inches high nailed in each corner. The top of these pins therefore projects from 2 to 3 inches above the edge of the box. These pins are strengthened in their position by having another bar, 1 inch square, nailed across the ends, and reaching from the top of the one corner pin to the top of the other. These cross-bars also serve as handles for carrying the boxes, besides being in other ways useful. In Jersey, and in many districts of Britain and Ireland, boxes about one-third smaller than above are preferred. These smaller boxes are much lighter to carry about, and the sets are planted direct from them.

Tubers Boxed.—The potatoes used may be of any variety, but where early maturity is the main object, only the earliest varieties are boxed. Only small or medium-sized potatoes are used, all over 1¼ inch and under 2 inches in diameter being considered suitable.

Cut Seed Unsuitable. — Cut seed cannot so satisfactorily be used, because the sets remain so long in the boxes, and such a quantity of the moisture evaporates from the sets that they ultimately shrivel up, and become so dry that the bud never starts into life.

Boxing the Seed.—The seed may be placed in the boxes any time between the end of July and the New Year, the most suitable time being probably September or October. At the latter end of July, all potatoes which are at that time dug and of too small size for table use may at once be put into boxes, and thus preserved for seed to the following spring. In the boxes they keep with very little loss, even although quite soft and green when put in, whereas if stored in the ordinary manner all would be lost.

Storing Boxes. — During autumn the boxes may be stored in any unused barn, byre, shed, or other house which is rain-proof. The boxes are placed in tiers one above the other to any convenient height, the corner pins and cross-bars of the one box supporting the weight of those above, the extra height of the pins over the depth of the box giving sufficient room for the ventilation of the tubers and growth of the sprouts.

When cold weather sets in, the boxes should be removed to some position where they will be free from the effects of frost. Very many are stored on the joists of byres, bullock-houses, &c., where the heat from the animals is always sufficient to start germination and keep out most frosts. Others, again, are stored in empty cheese-rooms and other houses specially built for the purpose, which are provided with artificial heat in the shape of a stove or other heating apparatus. It is not often that the heating apparatus requires to be called into use, but it is almost a necessity against occasional extreme frosts, and it comes in handy for pushing on late boxed or tardy germinating tubers.

Planting Boxed Seed.—Planting is generally begun about the first of March, and in the most favoured localities a little earlier. Before this system was adopted, the localities which now use it generally began to plant in January or February, but now there is nothing to be gained by beginning so early, and much may be lost by frost cutting off the haulms of the plants after they have come through the ground. Previous to planting, the boxes with the potatoes in them are removed to the field in carts, and distributed along the side of the land, being placed in much the same way as sacks of cut potato-sets are put down before planting begins.

The *sprouts* at this time may be from 2 to 4 or more inches long, but instead of being white and brittle like those seen on potatoes in an ordinary pit, they are blue or pink according to variety, are tough, and not at all readily broken off. The tubers are generally planted direct from the boxes. If the large-sized box is used, two planters carry one between them; while if the smaller one is adopted, each planter has a separate box. If the sprouts are comparatively short, the sets may be transferred from the boxes to the planters' aprons in the usual way of carrying cut potato-sets; but by doing so the plants get much rougher handling, and a few are always more or less damaged.

Seed per Acre.—The seed required to plant an acre on this system varies very considerably according to the size of the potatoes used. Where the smallest size of potatoes are planted, 30 boxes containing from 3 to 3½ stones will be found amply sufficient, even where 26-inch drills are made, and close planting in the drill is followed. If, however, the potatoes are larger, say about 1¾ inch in diameter, 50 boxes of the same capacity may not be more than sufficient. In the former case, therefore, 12 cwt. or so will be sufficient for an acre of land, while a ton may be required in the latter.

Advantages of the System. — The reasons of the success of this system appear to be: 1st, the gain in time by the sets being sprouted before being planted; and 2nd, the long period of drying to which the seed is subjected in the boxes seems to enable the plant to mature its tubers in the following season more quickly than if it had been stored and planted in the usual way.

A crop from seed which has been boxed is usually ready to lift three weeks earlier

than one grown from similar seed which has not been boxed.

In the forcing of rhubarb, hyacinths, narcissi, spiræa, &c., the plants or bulbs must all be rested a certain time before growth will begin, no matter what heat and moisture are used; and in the case of the potato, the dry-keeping in the boxes instead of the damp-keeping in pits appears to have a somewhat similar effect, as more time is gained than is accounted for simply by sprouting. An unsprouted crop may indeed look as far forward as a sprouted one, and yet not yield the same weight of tubers.

The Lazy-bed System.

Another mode of field-culture for potatoes is in *lazy-beds*, very common in Ireland. This system is becoming less general on arable land, though on lea-ground it gives very good results, and seems indeed to be best suited to certain circumstances. In the island of Lewis drill-sowing was at one time adopted, but found unsuitable for the soil and climate, and the lazy-bed system had again to be resorted to. The usual method is to remove a line of turf along the margin of the proposed lazy-bed, after which a slight covering of dung is given, and the next line of turf turned over green side under upon the top of the sets. The next line is turned over without sets, then dung, &c.,—this proceeding being adopted along the whole bed, until finished, after which a trench is cut or formed round the edges to carry off any surplus moisture.

In reference to Ireland, Martin Doyle says: "In bogs and mountains, where the plough cannot penetrate through strong soil, beds are the most convenient for the petty farmer, who digs the sod with his long narrow spade, and either lays the sets on the inverted sod,—the manure being previously spread,—covering them from the furrows by the shovel, or, as in parts of Connaught and Munster, he stabs the ground with his *loy*,—a long narrow spade peculiar to the labourers of Connaught,—jerks a cut set into the fissure when he draws out the tool, and afterwards closes the set with the back of the same instrument, covering the surface, as in the case of lazy-beds, from the furrows.

"The general Irish mode of culture on old rich arable lea is to plough the fields in ridges, to level them perfectly with the spade, then to lay the potato-sets upon the surface, and to cover them with or without manure by the inverted sods from the furrows. The potatoes are afterwards earthed once or twice with whatever mould can be obtained from the furrows by means of spade and shovel. And after these earthings, the furrows, becoming deep trenches, form easy means for water to flow away, and leave the planted ground on each side of them comparatively dry.

"The practice in the south of Ireland is to grow potatoes on grass-land from one to three years old, and turnips afterwards, manuring each time moderately, as the best preparation for corn, and as a prevention of the disease called fingers-and-toes in turnips. In wet bog-land, ridges and furrows are the safest, as the furrow acts as a complete drain for surface-water; but wherever drilling is practicable, it is decidedly preferable, the produce being greater in drills than in what may be termed, comparatively, a broadcast method."[1]

RAISING NEW VARIETIES OF POTATOES.

For the success of the potato-growing industry the raising of new varieties of tubers is of the utmost importance.

New Varieties Resisting Disease.—That baneful fungoid disease, known as *Peronospera infestans*, played such havoc with the older varieties in use when it made its earlier attacks in the country, that a great cry arose for new sorts, which it was believed would be less liable to the malady. Experience showed that there is foundation for this belief, yet varieties which seem to be almost disease-proof when first introduced gradually lose vitality, and have ultimately to be abandoned because of their liability to disease. Most new sorts begin to show signs of this deterioration in ten or twelve years—many, indeed, in a shorter time. It is thus of the greatest importance that the creation

[1] Doyle's *Cy. Prac. Husb.*—art. "Potato."

of new varieties of potatoes should be encouraged, and with this object in view we produce here the following description of the process, prepared for this work by Mr John Speir, Newton Farm, Glasgow. The illustrations used in describing this process are taken (by the kind permission of the publishers, Messrs A. & C. Black) from Balfour's *Elements of Botany*.

Potato-seeds.—As most people know, new varieties of potatoes are raised from the plum, as it is popularly called. The plum holds the same relation to the potato-plant as the apple does to the apple-tree. It is the fruit, and, within, the fruit contains the seeds. The seeds of the apple or orange every one is familiar with. The potato also, like them, has its seeds contained in a mass of pulp, which, however, unlike the apple or orange, is not of such a pleasant taste. Hence the seed of the potato is not so well known.

Seedless Varieties.—Some varieties of potatoes do not throw up flowers, and therefore cannot have plums. Seed must thus be looked for only on those varieties which have flowers. Again, all varieties which have blossoms do not have plums, as some appear unable to set a single bloom, unless on very rare occasions. With plants, as with animals, in-breeding, if I may so express it, although not at first very hurtful in its effects, is very liable if persisted in to have a deleterious influence on either plant or animal—the stamina of both evidently becoming so reduced, that they fall a ready prey to disease.

Cross-fertilisation. — The methods which nature has adopted in plants, not exactly to prevent self-fertilisation, but to favour cross-fertilisation, are numerous, curious, and very interesting. Darwin proved beyond doubt that certain plants if self-fertilised would attain a moderate size; if cross-fertilised from plants growing alongside of them, they would attain a much greater size; and if fertilised from plants of the same variety grown on different soil, some miles away, their size would be still further increased.

These facts are of very great importance to the raiser of new varieties of potatoes. In fact, it is principally on cross-fertilisation that he relies for success. A new and quite good enough potato may be raised from seed where no intentional cross-fertilisation has been done, but the chances are that such a plant has been self-fertilised, or cross-fertilised, by a plant of its own variety. The consequence will be that a much smaller proportion of the seeds sown will produce plants having vigorous constitutions, than if a different and improved variety from a dissimilar class of soil had been used in fertilisation.

Male and Female Organs.—Among plants, as among animals, there are male and female organs, which in most plants are situated in the same flower. On some, however, the male blossoms are on one part of the plant and the female ones on another, while in others the males and females are on separate plants.

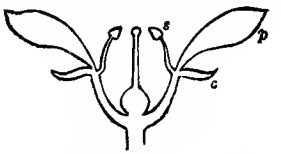


Fig. 585.—*Section of a flower.*
c, Calyx. *p*, Petal. *s*, Stamen.

In fig. 585 is shown a section of a flower, in which *c* represents the calyx or short green hard leaves at the base of most flowers, *p* is the petal or flower proper, *s* is a stamen, or male part, of which there are two shown, one on either side of the central figure; while the pistil, or female part, is seen in the centre.

Fig. 586 is a horizontal section showing the organs of fructification of the potato, where the calyx or outer scales are five in number, and the blossom proper contains five petals, the one overlapping the other. Inside the circle of petals are shown five stamens, and inside that again the pistil, with seed-pod at its base.

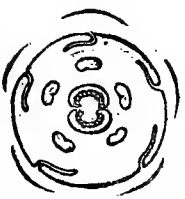


Fig. 586.—*Horizontal section.*

In fig. 587 is shown a vertical section of a potato-blossom, in which *c* represents the calyx; *p*, the petals, or bloom proper; *e*, the stamens; *s*, the pistil; and *o*, the ovary or seed-vessel. At a certain age the stamens throw off from their

top a very fine powder, which is called pollen.

Fig. 588 represents a stamen in the act of discharging its pollen, which in some cases is thrown out through slits in the anther, *a*, or top part, while in others, like the potato, it comes out through holes or tubes.

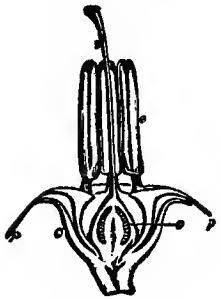


Fig. 587.—*Vertical section of a potato blossom.*

c, Calyx. *p*, Petals.
e, Stamens. *s*, Pistil.
o, Ovary.

Fig. 588.—*Stamen discharging pollen.*

a, Slits in the anther.
p, Pollen.

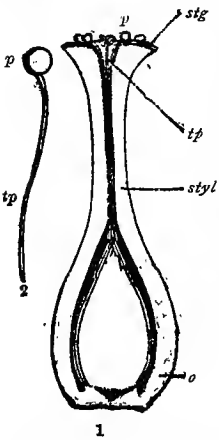


Fig. 589.—*Pistil with pollen-grains on top.*

(1) *stg*, Stigma.
p, Pollen-grains.
tp, Tubes.
styl, Style.
o, Ovule.
(2) *p*, Pollen-grain.
tp, Its tube.

Fig. 589 is a pistil with pollen-grains on the top. The uppermost part, *stg*, is called the stigma, with pollen grains, *p*, adherent to it, sending tubes, *tp*, down the conducting tissues of the style, *styl*; the ovule is *o*; while in (2), *p* is a pollen-grain separated, and *tp* its tube.

Fig. 590 represents a pollen-grain very much magnified, showing three points where the tubes come out, one of which is considerably elongated.

Fig. 591 is a very much magnified vertical section of the style and stigma of the pistil, showing two pollen-grains on the top, throwing out their protruding tubes which descend to the ovules.

Process of Cross-fertilising.—When it is wished to cross-fertilise a potato-blossom, the flower is held steadily in the left hand, while with the right the stamens, or male parts of the flower, are cut away with a pair of fine-pointed scissors, or a sharp and fine-pointed knife. These are the parts marked *s* in fig. 585 and *e* in fig. 587, all of which must be destroyed soon after the bloom has expanded. Three or four days afterwards, on a bright clear day, the bloom of some plant which it is intended to cross with the one on which we have operated, is taken, and the pollen scattered on the stigma of the mutilated

Fig. 590.—*Pollen-grain magnified.*

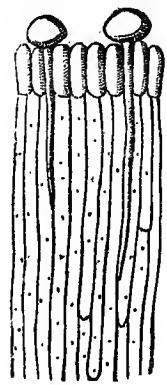


Fig. 591.—*Vertical section of style and stigma magnified.*

plant. If the anthers are ripe, this can be very readily done by bending the stamens back with the tip of one of the fingers, then letting it spring forward again, when the pollen will be thrown off. Another way is to brush them with a dry feather or small camel-hair brush, which takes on a certain amount of the pollen-grains, which, by drawing across the stigma, are in part conveyed to it. The top of the stigma always contains more or less glutinous matter, on which the pollen-grains readily stick.

If it is desired to make the cross-fertilisation very accurate, and to be certain that no other pollen-grains are conveyed to the stigma by insects or the wind, the bloom may be tied to a stake and covered with a small fine canvas bag, or a glass globe.

For the purpose of raising seedling potatoes these precautions are, however,

unnecessary. It may be here mentioned that when a potato-bloom has been only a day or so opened, the organs of fructification then have a more or less greenish tint, the colour of the stamens and pistil being as yet only partially developed;—that is *the time to cut away the stamens.* At first the stamens are much shorter than the pistil, but as they approach maturity they become more of one length.

Fig. 592 represents the ripened plum, while fig. 593 is one cut across the centre, showing the seeds inside. According to

Fig. 592.—*Potato-plum.*

Fig. 593.—*Plum cut, showing seeds inside.*

variety the size of the plum may vary from that of a cherry to the size of a damson plum. Fig. 594 represents a magnified seed.

Marking Fertilised Plum. — In order that the plum of the flower on which cross-fertilisation has been practised may not be mistaken for some self-fertilised one, each bloom as operated on should be tied to a stake, to which a label is affixed, giving the name of parent, date of cutting the stamens away, date of fertilisation, and name of the variety used for crossing. Flowers thus labelled are easily found, as the white stakes and labels are good guides, and worth all the labour for that alone.

Fig. 594.—*Potato-seed magnified.*

Ripe Plums.—When the plums are thoroughly ripened, they should be gathered and the seeds separated from the pulp. The ripening stage is easily known, because as maturity is approached the stalk bearing the plum first withers, then gradually shrivels up, ultimately becoming so dry that it breaks, when the plum drops on the ground. If left to themselves the plums soon rot, the hard seeds alone remaining fresh, and if these are kept moderately dry and out of the reach of birds they remain dormant till spring, when they begin life anew.

Securing and Storing Seeds.—For experimental purposes, however, the plums should be cut up when ripe, and the seeds picked out and dried under cover, preferably on a window-sill, or in a dry greenhouse; and when dried sufficiently to keep during the winter, they may be stored away in any dry situation. Instead of thoroughly drying the seeds, they may be mixed with dry earth or sand, and thus stored during the winter, the whole (the earth or sand and seeds) being sown in a seed-bed in spring.

The plums may even be treated in this way, by surrounding them with dry earth and letting them so remain till spring, by which time the pulp will have rotted or dried up, leaving the seeds more or less mixed up with the soil. Either plan may be adopted successfully enough, but personally I prefer the first.

Sowing the Seed. — In spring the seeds may be sown under glass any time during February, March, or April, the young plants being kept under glass, particularly at nights, until all risk of frost is gone. If no glass is at hand, the sowing of the seed should be deferred till April or May, when it may be sown thinly on any garden soil in a small bed by itself.

The Young Seedlings. — In the month of May the young seedlings should be planted out, in rows not less than 20 inches apart, with 1 foot between the plants. If the seeds have been raised from strong-growing varieties the seedlings will be all the better of more space; while if they are from smaller-stemmed varieties, thay can do with less space. If the ground is dry-bottomed, they should be planted in the bottom of the drills, so as to give a suitable opportunity for thoroughly earthing them up. But if the young plants are likely to run any risk of being soured at the root by heavy rain they will be better planted on the flat, the earthing up in either case being done as the plant grows. If moderately manured, and kept in good clean order, the plants will soon cover the ground, the time they will take to do so being not very much longer than if ordinary potato sets had been used.

Lifting and Selecting.—At the end of October, or beginning of November, storing should commence, when the experimenter's real difficulties begin. When storing, all varieties of a very bad shape, coloured or partly coloured skins, or bad colour of the flesh, should at once be rejected, as their preservation will likely only lead to trouble and expense, with very little chance of any corresponding gain.

The first year all plants not positively bad should be preserved, and a note kept of any peculiarities of growth, shape, colour, size, or productiveness of each.

Storing Seedling Potatoes.—With many experimenters, the separation and preservation of, it may be, several hundred varieties has been a serious drawback to their continuing the search for improved kinds. This, however, may be easily overcome in the following manner: A number of ordinary drain-pipes should be procured, and, for the first year's crop, the smaller the bore the better. One end of the pipe having been closed by a small wisp of hay or straw, the tubers of each variety are put in along with their number, when another small portion of straw, or piece of turf from an old pasture, is put on the top, then another variety, and so on till the tiles are all filled. The first year each tile may hold several varieties, whereas the second year one variety may be more than enough for one narrow-bored tile, in which case two may be used, or larger-sized ones procured. Small strips of wood, coated with white lead, and marked with an ordinary lead pencil, serve for numbering each lot; or pieces of tin, with the figures stamped on, may be used, if a set of figure stamps can be procured. After packing, the tiles may be built up in a heap, and covered as if it were an ordinary potato-pit, when they will require no further attention until planting-time in the following spring.

Period of Development. — It is a common belief that seedling potatoes require several years to form ordinary-sized tubers. Such, however, is not the case, as even the very first year many of the varieties may yield potatoes of a medium size and upwards, while the second year all worth preserving should have one or more full-sized potatoes.

Second Year. — When the potatoes are taken out of the pit or clamp the following spring, they may be planted in the usual way, and at the usual time, no particular advantages of soil, situation, or manure being given, in order to facilitate the elimination of the worthless varieties as soon as possible.

At the end of the second year they should again be stored in tiles as formerly. This time each variety will require one or more tiles for itself.

The selection must this year be much more searching than the former one, and instead of rejecting only what appeared to be positively bad varieties, those only should be kept which show really good points, or some noted peculiarity.

If notes have been taken during both the growing seasons of the robustness, earliness, lateness, liability to disease, or other peculiarity of the plants, the grower will be greatly aided in his selection.

Third Year.—The third year, only tubers should be kept which show positively some good points, all others being laid aside for consumption. In this way the list will be gradually reduced each autumn and spring, as many good cropping varieties will be found to be bad keepers. A large portion of the plants will thus be rejected every autumn, with a smaller portion in winter and spring, as some which have stood the test of several years may be found not to keep well, or to cook badly.

Retain only Superior Varieties.—After the fourth year, no variety should be kept which the *grower does not consider better than those already in cultivation*, because to propagate any that are not superior to those already in use, undoubtedly *in the end will be sure to bring pecuniary loss on the grower.* It is on this rock that most raisers of new varieties wreck themselves. They find it difficult to cast away seedlings on which they have expended much time and care: to do so appears to them like sacrificing their own children. For want of courage to apply the pruning-knife severely enough, they continue to propagate and keep in existence a large number of varieties which are of little merit. The consequence is, that in the end they become overwhelmed with vari-

eties which are of no commercial value, and most likely give up the work.

Need for New Varieties.—At present there are more than enough varieties of potatoes in commerce or cultivation. Unfortunately, however, there are only a few good ones, so that the field for research is not only a wide but a very varied one. The qualities requisite to make a first-class early, medium, or late potato are so many, and even good varieties retain these for such a short time, that there is likely always to be a demand for really first-class varieties. Although the personal attention requisite may be too heavy a drag on the ordinary farmer, who already has as much to do as he can well accomplish, the raising of new varieties of potatoes might well form a very suitable and interesting pastime for a proportion of our farmers' sons and daughters, as well as older farmers and gardeners, who have the time to spare.

RAISING POTATOES.

The raising of potatoes is a part of the work of the farm which demands careful attention. It requires a great deal of manual labour, even when machines are used in digging the tubers.

Time to Lift Potatoes.—Potatoes indicate fitness for being lifted by decay of the haulms. As long as these are green, the tubers have not arrived at maturity. In an early season some potatoes ripen before October; and although the weather should continue fine, it is best to let them remain in the ground until all the corn crops have been carried in. But in ordinary seasons the corn is cut down and carried before the potatoes are ready for lifting. In this case the potatoes should be lifted just when the haulm has almost completely died down, but before it has become bleached. There is the minimum of disease at this stage, and the longer the tubers are left in the ground after this the greater the risk of injury by disease.

Methods of Potato-raising.—Potatoes are harvested in three different ways —viz., by the digging graip or fork, by the plough, and by the potato-digger.

Raising Early Potatoes.

The practice of consuming potatoes before they are fully matured is steadily increasing. These potatoes are usually raised by the graip, because at that time the tubers have a firm hold on the roots, and are themselves so tender in the skin that, even if the tubers could be separated from the roots, they would be so bruised by the plough or digger that the damage done might be more than the total cost of raising them by the graip. By careful working, the ordinary steel graip or dung-fork may be used in digging potatoes without any serious injury being done to the tubers. There are, however, special kinds of potato graips or forks which are often used, one of these being shown in fig. 595. A graip of an improved pattern has triangular prongs, about an inch broad at the top and tapering to a fine point.

Fig 595.—*Potato-graip.*

The digging of early potatoes begins in June —even earlier than that in the Channel Islands.

Raising by the Graip.—In raising potatoes by the graip, each person, as a rule, digs one or two drills at a time. In some districts digging is done by men, women or boys doing the gathering; but in many cases, in Scotland, where the drills are narrow and the land light, as in the districts where early potatoes are grown, women occasionally do the digging, but even there digging may be said to be generally done by men, and the gathering by women or boys.

Barrels for Early Potatoes.—At this season of the year potatoes are sent to market in barrels holding 1½ cwt., barrels being used because in them the potatoes do not rub so much the one against the other in handling as they do in bags, in which their skins get ruffled and torn.

While the potatoes are being gathered, the tubers over 1½ inch in diameter or thereby are put into one basket and those under that size into another. The large ones are put into barrels on the spot without weighing, all barrels used being about the one size.

Preparing Barrels.—As a rule, the barrels have been used previously for bringing flour from America or from the home mills, and before being employed for potatoes they are strengthened by an extra hoop or two, and strings put on the top. For this purpose six or eight half-inch holes are bored in the staves of the barrel an inch or more from the top. Cord, three-eighths of an inch thick, is then taken and passed through one hole forward to the centre of the barrel, and then back through the next hole. A knot is now put on each end of the cord on the outside of the barrel, and large enough for the cord knot not to pass through the hole. The other holes are then roped in the same way, when the barrel is ready for use.

Filling Barrels.—When the barrel is being filled, a very few of the best-shaped potatoes are dropped into a basket at the side of the barrel, and when about filled, the barrel is completed by putting as many as are necessary of those in the basket on the top. A few green potato-stems are now taken and packed firmly over the top, and slightly above the rim of the barrel. A stout string, a foot or so in length, is then put through each of the loops of rope fixed on the top of the barrel, which, when tightly drawn and knotted, securely holds down the top.

Handling Barrels.—In letting the barrels down from a man's shoulders, or from a cart, they are always dropped on the mouth. If dropped in any other manner the barrel would run a great risk of being damaged.

Speedy Marketing.—Where the circumstances permit, the usual custom is to send as many of the potatoes which have been dug on any particular day to the railway station that evening, so that they may be carried during the cool of the night to the place where they are to be consumed. Early potatoes being soft and immature, very soon lose their flavour, and deteriorate in quality, if allowed to lie about.

Small Potatoes.—As soon as the crop has begun to harden and ripen a little, the small potatoes are usually carried to a bare smooth place in the field, where they are redressed, the tubers over 1¼ inch or so being set aside for sale at a low price early in the season, and for seed purposes. Those tubers under an inch or inch and quarter in diameter are used for feeding cattle or pigs.

Medium-sized Potatoes.—The medium-sized ones, or seconds as they are commonly called, when they are to be preserved for seed, are at once packed in the sprouting boxes referred to on p. 308, and carefully stored in any well-ventilated shed or empty house. Even although very immature, they can be preserved in this way with comparatively little loss, whereas were they stored in the usual way in pits till the end of the year, before putting them in the boxes, a large proportion of them would be spoiled.

Disease.—Disease rarely makes its appearance in time to do harm to early potatoes, but later on, when it is plentiful on the foliage, although scarcely perceptible on the tubers, the small seed, even although fairly well matured, keeps very much worse, and is often almost entirely lost. The reason is supposed to be that in digging, the disease spores, owing to the shaking the plant receives to separate the tubers from the roots, are shed from the leaves over the potatoes, where they vegetate and live after the potatoes are stored. Any seriously diseased potatoes should at once be separated, but tubers only slightly affected may be thrown into the basket containing the small ones, to be afterwards rejected if the small ones are dressed for seed purposes. If the small tubers are not to be used for seed, they, along with the slightly diseased tubers, may be used as food for cattle or pigs.

Raising Late or Main-crop Potatoes.

As already indicated, the later varieties which form the main bulk of the potato crop are not usually raised till after the grain crops have been harvested. Indeed, the raising and storing of late potatoes are seldom begun before the advent of October. When the potato leaves have been dead for a couple of

weeks or so storing may begin in earnest. The work now to be accomplished in a limited time is too great for such a slow tool as the graip, and the potato-digger is therefore called into use.

Potato-digger.—The modern potato-digger is an ingenious contrivance which does its work well and is extensively used all over the country. The general type is indicated in the illustration of Jack's digger in fig. 596.

Speed of Potato-diggers. — With three good sharp-moving horses, and in a fairly large field, where everything is in readiness for it, and a sufficiency of gatherers are at hand, the digger will accomplish from 4 to 5 acres per day. If digging is done only one way, as is

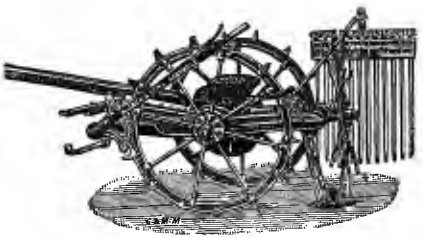


Fig. 596.—*Potato-digger.*

the usual custom on small farms or on steep land, from 2 to 2½ acres will be a good day's work.

Preparing for the Digger.—When the digging is to be done one way only, one drill, and in many cases two drills, should be dug by the graip or plough along the side at which a beginning is desired to be made before the digger is brought on the field. Besides, if the head-ridges have been planted with potatoes, which they occasionally are, one drill should be dug next to the hedge all round the field, and the potatoes from it gathered. The digger may then commence at any convenient corner and go round the field, taking a new drill each time till the whole of the head-ridge drills, and an equal number at both sides, are dug.

Gatherers Required.—If there is no disease in the crop, and if the crop is moderate, and all the potatoes large and small are thrown into one basket, from twenty to twenty-four persons will keep a digger constantly digging, both ways. If there are diseased tubers in the crop, or if the small and diseased are to be in any way separated, thirty to thirty-two persons may be required to keep a digger going, according to the weight of the crop and amount of diseased tubers to be taken out.

Arranging the Gatherers. — The gatherers should be arranged in pairs, or singly as is thought most desirable, each plan according to circumstances having its advantages. If there is no disease, and the small tubers are not taken out, two baskets will be sufficient for each gatherer; but if the diseased or small tubers are to be separated, three baskets at least must be given to each.

Before beginning, the land should be measured off into equal lengths for each gatherer or pair of gatherers, a lath, twig, pole, or other mark being put in where the one's lot ends and the other's begins.

The gatherers begin to collect from the end of their division nearest to where the digger starts, and work towards the other end.

Assorting Potatoes.—A general practice now is to gather all sizes of sound tubers into one basket, and to have them assorted afterwards by one of several good machines designed for the purpose.

Harrows following Digger. — As soon as the first space is gathered, a boy should follow with a pony or other light quiet horse, yoked to a single division of a set of zigzag harrows, or, better still, to a half of a set of the old pattern of hinged harrows. The latter is about the proper breadth, while the former is a little too narrow. The harrow should be of moderate weight, but should have good long tines, so that it may fully search the loose earth thrown out by the digger, and bring the buried potatoes to the surface.

As soon as the harrow has passed the first division, the gatherer of that piece of ground picks up the exposed potatoes, and works towards the end where a beginning was made. By the time the gatherer has collected the potatoes exposed by the harrow, the digger will again be round at the place where a beginning was made—that is, if the number of gatherers has been properly pro-

portioned to the work which the machine can do. In the next and succeeding drills the same routine is of course followed.

Collecting Carts.—When the digger has made a circuit of the field, there should follow one or more carts, into which the baskets should be emptied when full. The ordinary farm-cart (fig. 597) is used in carting potatoes. The emptying should be the work of the man in charge of the cart, and not the gatherers.

Diseased Tubers.—If many diseased or small tubers are taken out, a separate cart will be required to carry these away as soon as the baskets holding them are full, or nearly so. With late varieties it is specially important that no tubers showing the slightest symptoms of disease should be stored with the sound potatoes. Potatoes that are only slightly diseased may be of some value at digging time; later they are not only of no value, but they become positively hurtful by conveying the disease to those healthy tubers with which they come in contact.

Tubers free from Earth.—The gatherers should take care to put the full baskets far enough to the side to prevent the machine throwing the earth on them when passing, as the more free potatoes are from earth, the less they are liable to sprout in the pit.

While the headlands and drills along the side of the field are being dug in above

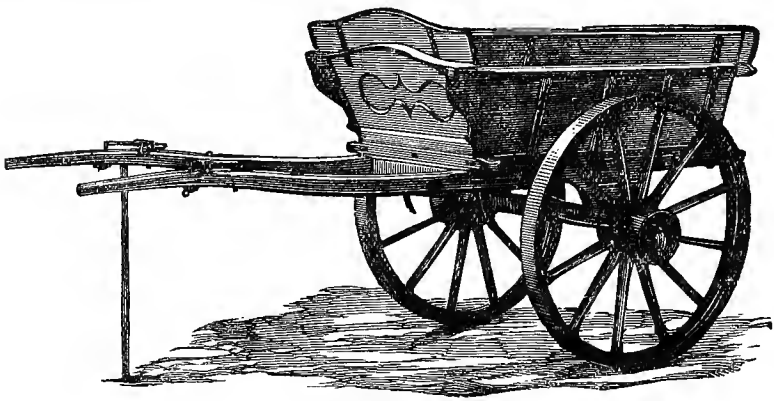


Fig. 597.—*Jack's farm-cart.*

manner, a single drill should be dug by hand from one end of the field to the other—say sixty drills from the side of the field. If there are not sufficient persons to dig and gather such a drill, it may be done by the double mould-board or other plough, if the land is thoroughly clean and the shaws quite rotted. The harrow must of course follow the plough in the same way as it follows the digger, and in many cases it will be advisable to turn the drill to one side with the single plough, and as soon as the potatoes are gathered to turn it back again to the other side, after which the harrow should level the land before the digger comes along the next drill.

Process of Digging.—One drill having been cleared by any of the above methods, the regular digging of the field should begin. According to the side of the field from which the drills were counted, the digger should either go along the outside drill, and back the one next to the hand-dug one, or else along it first and then back the one next the fence. Digging is proceeded with in this way until the space dug at the side next the hand-dug drill is at least 15 or 20 feet wide, after which the digger may go down one side of the hand-dug drill and back the other.

This course is necessary, or at least advisable, to allow space for the digger to throw out the potatoes to each side, and still leave enough space between the two rows of ungathered potatoes for the carts to go along without bruising the potatoes.

The carts should not pass each other in this narrow space, but come in empty at the end farthest from where they are to be stored, and fill towards the other end. After a space has been dug quite wide enough to allow the carts sufficient space, and when it becomes inconvenient for the carters to lift the potatoes from both sides at once, owing to their increasing width, the carts should follow the direction of the digger, and empty the baskets along the one side, and then return along the other.

When the space so dug equals the number of drills remaining next the side of the field, the digger should then go round about them until they are finished. By proceeding in this manner, the greatest amount of land is dug with the least travelling across the ends, and fewest shifts of the gatherers.

It is seldom the headlands are sufficiently wide to allow the digger to get easily out and in without missing some of the potatoes. To prevent loss here, it is advisable to have a person with a graip at one or both ends, digging as much as gives the horses quite space enough to turn easily.

One-way Digging. — If the land is steep, or the number of gatherers limited, it may be advisable to dig only along one side of the field. In this case digging is always done down-hill, the machine returning up-hill out of gear. As in the other system, the gatherers have each their own division; but digging drills at intervals through the field by hand is done away with after it has been properly opened up.

Horses Required. — While three horses are required to work the digger when digging both ways, two may do where only one side is dug. In the latter case the number of gatherers is of course correspondingly small.

There are few operations on the farm which require greater personal supervision than potato-digging.

Adjusting the Digger.—Before beginning, the farmer or other person in charge should examine the digger carefully and see that it is in good working order. They should in particular see that the graips or forks are the proper distance behind the sock, and the sock sufficiently below the graips to allow a considerable proportion of earth to pass through, without compelling the forks to throw it to the side, or making it so wide that the potatoes pass through without being brought to the surface by the forks. If the forks are about three-fourths of an inch behind the sock, and the sock fully an inch below their points, it will be found that the digger is easier drawn, and scatters the potatoes better than if either are kept wider or narrower.

Depth of Digging. — Whenever a commencement has been made in digging, particular attention should be directed to the depth at which the digger is working. If too shallow, some of the potatoes will be cut, and others left in the ground below the reach of the harrows; and in both cases they are, practically speaking, lost. A digger working badly in this manner may cause as many potatoes to be damaged and left in the soil as would nearly pay for properly digging the whole crop. If, again, the digger is set too deep, owing to the extra quantity of earth which the forks have to displace, a considerable number more of the potatoes are covered than if it is set a little shallower, while the difference in draught will be not a little.

Adjusting the Sock.—The several causes which influence the depth at which the sock moves should be well understood by the person working the digger. The principal are the depth at which it is set, the depth of the drills in which the digger is for the time working, and the condition of the sock itself. After the sock has been set at any particular depth by the lever controlling it, the height at which the wheels stand thereafter regulates the level at which it moves. If the crop has been high-ploughed up, the space between the drills will be deeper; and the digger-wheels getting deeper compel the sock to go also deeper, so that high-ploughed drills require the sock set at less depth than where the drills are more flat.

Again, a new sock, broad and thin on the face, goes to a much greater depth with the lever set at any particular place than one badly worn, short and thick on the face. A worn sock may work satisfactorily enough on soft easy

land, such as moss or sand, while it would be of no use in a drier, harder, and firmer soil.

The most of the potatoes which have been raised by the digger and buried will, as a rule, be found a little out from the point of the sock. The centre of the harrow should therefore move along there. Contrary to expectation, the finer and more sandy a soil is, the more potatoes will be left in it after the digger. The reason for this is that the unseen potatoes are covered with a very thin coating of soil, which in great part would have rolled off and exposed the tubers had the soil been rougher.

Adjusting Force of Labour.—Where the labour of one person depends so much on that of some other, as in raising potatoes by the digger, it is of the utmost importance that each class of labour should bear a certain due proportion to all the others. As many gatherers should be provided as will keep the digger moving at a moderate, steady pace; and as many carts should be employed as will easily remove the potatoes when collected; while great care should be taken that each gatherer is provided with a sufficiency of baskets. Plenty baskets help considerably to steady working, for if a cart may at a time be a little longer in coming than another, the whole work is brought to a standstill if the baskets are full; whereas had a few more been provided, no interruption would have occurred.

Second Harrowing.—It is customary to harrow the land and gather all remaining potatoes as soon as possible after being dug. But if the work is at first carefully and methodically performed, this second harrowing and gathering will not pay expenses. If, however, a second harrowing and gathering are to take place, they should be done every evening, either by the horses from the digger and the whole company of gatherers, or by a separate pair of horses and another company of gatherers. In the potato-digging season the weather is so uncertain that it is impossible to say what a day or night may bring forth; and potatoes in dug land which have been subjected to rain or frost are rarely afterwards worth the cost of collecting. As potatoes collected after the harrows usually contain a large proportion of small, diseased, and damaged ones, they should invariably be put into a pit by themselves. They rarely keep so well as the ordinary crop.

Weather and Digging.—Potato-digging should not be persevered with during very showery weather, nor when the land is wet. A large proportion of the potatoes are left unseen in the land when the soil is damp and adhesive; and those tubers which are collected in a wet condition seldom keep well.

Plough Digging.

On farms where the potato-digger has not been introduced, or on fields very steep and otherwise unsuitable for the digger, the aid of a plough of one kind or other is usually invoked in lifting potatoes. In some cases the double mould-board plough is used; in others, it is the ordinary single furrow swing-plough; in others, the American chill plough; while not a few employ specially fitted "potato-ploughs."

Potato-plough.—The "potato-plough" may be an entirely distinct implement, or an ordinary plough fitted with a potato-raiser—a series of iron or steel fingers running out from one or both sides of the body of the plough.

The specially fitted ploughs are certainly superior to the ordinary ploughs for lifting potatoes, yet it is generally agreed that if a separate implement is to be procured for this work, that implement should be the potato-digger proper.

The original potato-raiser attached to an ordinary plough, designed by the late Mr J. Lawson, Elgin, is shown in fig. 598; but numerous modifications have been introduced by different makers. The cutter of the plough should be removed, so as to avoid injury to the potatoes.

Digging by Drill-ploughs.—If it is desired to raise potatoes by the double mould-board plough, every second drill should be split by it, the mould-boards being set much wider than for drilling, or removed altogether, and the potato-prongs put on. Each gatherer has a section to collect, in the same way as behind the digger. When nearly a half-day's work has been done by splitting every second drill, the ploughman then

begins and splits the remaining drills. All drills which have been split during the day should get a double stroke of the harrows before night, the gatherers all the time keeping close up to the harrows.

Harrowing.—As soon as the gatherers have collected their potatoes, a harrow should pass along in the same manner as was described in connection with the digger; and any tubers exposed by the harrow should be collected before another drill is turned over by the plough. The harrowing is a most important part of the operation of potato-raising, and one which should not be neglected, either when the plough or the digger is used.

Forking after Ploughs.—In many cases it is the practice to further scatter with the graip the drills which have been split by the plough. This makes more thorough work, leaving less to be done by the harrows, and making it easier work for the gatherers. But this forking, although much more speedily done than the forking of drills which have not been split, entails a good deal of extra labour.

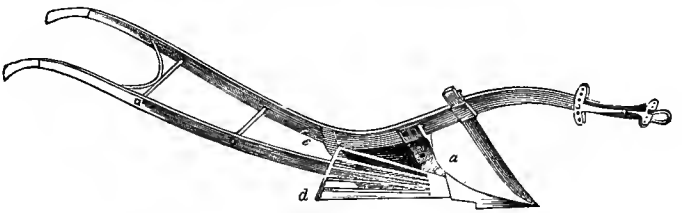


Fig. 598.—*Potato-raiser attached to a plough.*

a Narrow end of brander. *c* Upper angle of brander. *d* Lower angle of brander.

Improved Digger best.—Where a proper digger is not available, a plough of some sort should certainly be used to split the drills. But while lifting with the plough is a decided step in advance of lifting with the graip or fork, both methods are much inferior to lifting with the modern digger.

STORING POTATOES.

Supplies of Early Potatoes.—Formerly it was necessary to store a larger quantity of potatoes for use in winter, spring, and early summer than is now required. Early in spring large quantities of new potatoes are now imported from Malta and elsewhere; and as soon as these are exhausted, supplies come in from Jersey and early districts along the south coast of England. Then about the middle of June the first Ayrshire and Irish crops are generally ready, and this is at least a month, if not six weeks, earlier than potatoes could be depended on prior to 1860. Moreover, the nation as a whole would appear to be using fewer potatoes and more bread than formerly. And when new potatoes can be obtained at anything like moderate prices, they are preferred to old ones which have been stored.

Potatoes more difficult to Preserve.—For some reason or reasons not very well known, potatoes are now more difficult to store successfully than they were prior to the middle of last century. Then they could be stored safely in pits at least double the capacity which can be trusted now; and in what were then called potato-houses they were easily preserved many feet deep, while now they would spoil if kept two or three feet deep.

Field Pits.—Where large quantities have to be handled, storing in pits in the open field is the easiest, cheapest, and most satisfactory plan pursued at the present day. A situation is selected near the farmhouse, if possible, having a dry bottom and free working soil. There shallow trenches, from 2½ to 3 feet wide are made, running as nearly south by west and north by east as the lie of the land will permit. If the land is not thoroughly dry in the bottom, or is very clayey, no trench should be made, the potatoes being placed on the surface and piled up into long conical heaps, the sides

of the heaps being kept as steep as possible. Where this is done the heap of potatoes may be from 3½ to 4 feet wide at the ground. If the subsoil is naturally dry and open, a trench from 6 to 12 or 14 inches deep may be dug out between the two guiding lines. The earth taken out should be neatly packed on the sides, a considerable slope being given to the sides of the trench.

Prismatic Pit.—Into this trench the potatoes are emptied from the carts as they come from the field, the heap carefully and neatly built as high as possible by hand. This pit is known as the long or prismatic pit, and is shown in fig. 599.

Conical Pit.—A conical pit is often preferred for storing small quantities of potatoes. It is well adapted for small farms and cottars—the prismatic being used for storing larger quantities.

A common method of forming a conical pit is as follows: if the soil is of ordinary tenacity, and not very dry, let a small spot of its surface be made smooth with the spade. Upon this let the potatoes, as taken out of the cart, be built up by hand in a cone not exceeding two feet in height, which height will give the diameter of the cone at its base 6 feet. The potatoes are then covered thick with dry clean-drawn straw. Earth is then dug with a spade from the ground as a trench around the pit, fig. 599, the inner edge of which being dug as far from the pile

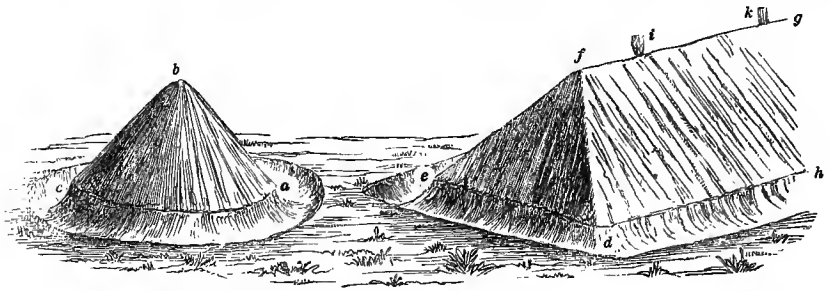


Fig. 599.—*Conical and prismatic potato-pits.*

a b c Conical pit of potatoes.
b Apex of cone.
c a Diameter of cone and inner edge of trench round the cone.
e d h g Prismatic potato-pit.
d h Side of pit.
d e End of pit.
f g Crest of pit.
i k Straw chimneys.

of potatoes as to allow the covering of straw and earth to be put upon it, about one foot. The first spadeful is laid upon the lower edge of the straw, round the circle of the heap—the earth being clapped down with the spade, to form a smooth outward surface. Spadeful after spadeful of earth is thus taken from the trench and heaped on the straw, until the entire cone is formed, which is then beaten smooth and round with the back of the spade.

The apex of the cone is about 3 feet 3 inches in height, and the diameter about 8 feet. The trench round the pit should be cleared of earth, and an open cut made at its lowest side to allow surface-water to run freely away.

When the soil is naturally dry, the pit may be dug out of the solid ground a spade-depth, and the height of the heap will be proportionately less. But unless the soil is as dry as sand or gravel, potatoes should be piled upon the surface of the ground.

A Yorkshire Method.—The following method of covering potato-pits is practised in Yorkshire and many other parts of the country: The prismatic pit is covered with a layer of straw 6 inches thick. The straw is practically in a "drawn" condition, having come from the threshing machine in *trusses*. A plank 1 foot broad and 8 to 10 feet long is then placed along the top of the pit, and the sides to the length of the plank are covered with an inch or two of soil. The plank is then moved on, and another length is covered with soil. In this way the top is kept free from soil, and even when more soil is added to the sides later in the year, it is left untouched. In

a time of severe frost potato haulms may be put over the top.

Ventilating Pits.—Small sheaves of straw are placed along the gutter left by the plank after its removal, on each of which a spadeful of earth is put to keep it in position. This straw provides thorough ventilation, and it, at the same time, keeps out rain and frost until the whole crop is secured, or opportunity is afforded of covering them more securely.

Instead of leaving a gutter the whole way along the ridge, it is the custom in some localities to only put in wisps of straw here and there, the rest of the ridge being covered with earth. Where the crop is thoroughly matured and firmly grown, such a provision against heating is probably ample enough; but in many seasons and in many circumstances, particularly with late varieties, it is not sufficient.

Heating.—As a rule, even the best ripened potatoes, after being put in the pit and closed on the sides, generate more or less heat, and give off moisture which passes out at the top, and through the earth on the sides. For this reason it is never advisable to heavily cover up potatoes when first brought in from the field, no matter how well ripened they may appear to be; for should a mild autumn and winter follow, premature growing, if not worse, will be almost sure to follow.

In order to check heating many farmers adopt the simple plan of only partially covering the layer of straw with earth at the outset. A covering of earth is put on the straw at the base of the pit, and again about its middle, leaving the straw uncovered with earth not only on the top but also along a section 8 or 10 inches wide, about 15 to 18 inches from the ground. When the pit is left in this way for a few days the potatoes rarely suffer from heating.

Seed Pits.—If the potatoes are intended for seed, the pits should be made specially narrow, in order to reduce premature sprouting to the lowest limit possible.

Storing Wet Potatoes.—Any potatoes which come in wet from passing showers, which are common at this season of the year, should be put in a pit by themselves, or along with those gathered behind the harrows. Potatoes stored wet rarely keep well. Where it can be carried out, the best plan is to take all carts which get caught in a heavy shower to the farm steading, and leave them there in an open shed till the potatoes are quite dry. Treated in this way, they are usually little the worse of getting wet, whereas they would almost certainly not keep well if put into the pit in a wet state.

It is advisable that any potatoes that may not be dry when stored should be cleared off as soon as possible after the whole crop has been safely secured.

Potato-pits are occasionally thatched in much the same manner as an ordinary stack, the ropes running lengthways and crossways, being fixed to wooden pins driven into the sides. All this trouble is, however, quite unnecessary, as the other plans are equally as secure, and cost much less. Many persons also put on a second covering of earth before putting on the thatch. This also is unnecessary, unless where thatch is very scarce and labour plentiful. Six inches of straw, with 6 inches of dry earth under, will keep out stronger frost than 18 inches of bare earth unthatched.

It is of great importance that the straw should be put on as early as possible after the crop is stored, and before the earth on the sides has become soaked with rain, as in the damp stage it takes in frost much more readily than when dry.

Potato-shaws as Thatch.—Instead of putting on ropes or earth over the top of the thatch, some farmers spread a thick covering of potato-shaws. This practice became common when the "Champion" potato with its rank shaws was introduced. It has not much to recommend it, however, as the cost of putting on and taking off the shaws is considerable.

Frosted Potatoes.—Potatoes are subject to damage by frost. When they have been exposed to frost they become soft and develop a sweet taste. The sweet taste gives place to sourness, and soon putrefaction follows.

THE TURNIP CROP.

It is not easy to over-estimate the importance of the part which turnips have long played in the agriculture of the United Kingdom. Their introduction as a field crop completely revolutionised the methods of farm practice.

Advantages of the Turnip Crop.—For the light land in the northern districts of the British Isles, where the climate is too cold for the sugar-beet or even the mangel crop, the turnip crop is of primary importance. It enables the farmer to clean and fallow his land, and at the same time to grow, even from poor light soil, an immense quantity of nutritious food for cattle and sheep. It has been said that the greatest improvement in arable farming during the last hundred years was due to the introduction of the turnip crop into the rotation.

The turnip crop has, to a large extent, given to Scottish agriculture the eminence it has attained, and it has made the eastern half of Great Britain the greatest cattle-breeding region in the world. If properly managed, the crop is a moderately reliable and valuable one on the lightest and shallowest of soils; its introduction has been of immense advantage, and its place in the rotation cannot be filled so well by any substitute which has as yet been tried.

On stiff clay soils its cultivation is not of so much advantage. The cost of reducing these to a proper tilth for the seed is great, and if the weather is either too wet or too dry, the crop is precarious and uncertain. Then clay land is liable to be injured either by carting the roots off the land or by the treading of sheep in consuming them upon it.

Unlike the potato crop, the turnip crop is usually consumed on the farm, and the unappropriated matter returned to the soil. With properly constructed dung-pits there should, therefore, by the growth and consumption of roots, be comparatively little waste of manurial elements, and consequently little exhaustion of the land.

Turnip-growing may be Overdone.—The serious injury which the turnip crop has so frequently sustained from insect and fungoid plagues, together with the heavy costs involved in its cultivation, have somewhat weakened the hold which it obtained on the affections of the British farmer. The decline in the price of grain has also tended, indirectly, to lessen the area under turnips. It has been contended, with a good show of reason, that the unfavourable experience with the crop has been in a large measure due to an attempt to grow roots upon the same land too frequently—that is, with too short an interval between the successive crops of roots. It has been clearly proved that the growing of roots, like most other things, can be easily overdone, and that the results of indiscretion with this tendency may be almost disastrous.

With this qualification, there are few who would not endorse what is said above as to the advantages of the turnip crop and the part it has played in building up the fabric of British agriculture.

INTRODUCTION OF TURNIPS.

Like that of many other cultivated plants, the history of the turnip is obscure. According to the name given to the swede in this country, it is a native of Sweden; the Italian name *Navoni de Laponia* intimates an origin in Lapland; and the French names *Chou de Lapone*, *Chou de Suède*, indicate different origins. Swedes, it is believed, were first cultivated in Scotland in 1777 by a Mr Airth, who then farmed in Forfarshire, and who obtained the seed from a son who was settled in Gothenburg. Mr Airth sowed the first portion of seed he received in beds in the garden, and transplanted the plants in rows in the field. In this way he succeeded in raising good crops for some years, before sowing the seed directly in the fields.

It is probable that the yellow turnip originated, as supposed by Professor Low, in a cross between a white and the swede, and, as its name implies, the cross may have been effected in Aberdeenshire. The origin of the yellow

turnip must therefore, on this supposition, have been subsequent to the introduction of the swede.

It is remarkable that no turnips should have been raised in this country in the fields until the end of the 17th century, when they were lauded as field-roots as long ago as the time of Columella, and even then the Gauls fed their cattle on them in winter. The Romans were so well acquainted with turnips, that Pliny mentions having raised them 40 lb. weight. Turnips were cultivated in the gardens in England in the time of Henry VIII.

VARIETIES OF TURNIPS.

The varieties of turnips now in use are very numerous. Of the Swedish turnip (*Brassica campestris, rutabaga*—smooth-leaved summer rape) there are over 20 field varieties, more or less widely cultivated; and of the common turnip (*Brassica campestris, rapa*—rough-leaved summer rape) and hybrids there are more than 50 varieties in cultivation.

Swedes.—The Swedish turnip has a blue-green smooth foliage. It is a comparatively slow-growing plant, and therefore requires to be sown earlier than the common turnip. It requires for its successful growth, and will resist without injury, a greater degree of heat; is less watery; of harder texture; will stand several degrees of greater cold without injury; and will keep longer than the common turnip. The bulbs of some of the varieties are green-topped; some are purple or bronze-topped. The purple-topped varieties are usually more or less tankard in shape (*b*, fig. 600), and thus stand farther out of the soil. In consequence, they are more apt to be injured by severe frosts, and should be lifted and

Fig. 600.—*White globe.* *Purple-top swede.* *Green-top yellow.*

stored early. From their habit of growing well out of the ground, they are thought to be better suited for shallow soils than the green-topped varieties, the general shape of which is globular. The bulbs of the latter are more deeply seated in the ground, and are thus better protected from winter frosts.

Common Turnips. — The common turnips have rough foliage of a more decided green colour. The yellow-bottomed varieties are looked upon as a cross between the swede and the white turnip. They grow more rapidly than the swede, and come to maturity sooner. They may therefore be sown successfully much later. They will grow on a poorer soil, and in a colder climate. The bulbs contain less solid matter, and are more easily injured by hard frosts. They should therefore be used or pitted sooner than is necessary for swedes.

There are numerous hybrid varieties which are usually soft in flesh, tankard in shape, and most of them ill adapted for resisting hard frosts. The white-bottomed varieties are even more rapid in growth, more soft in texture, more easily injured, and more watery than the yellow-bottomed varieties.

Some varieties of the yellow-fleshed are green, some are purple-topped. The white-fleshed varieties are white, green, grey, purple, or red-topped. The green-top yellow turnip is shown in *c*, fig. 600. The white globe, shown in *a*, fig. 600, is an excellent turnip for early use, but is readily injured by frost.

New Varieties. — In recent times much has been done by enterprising firms engaged in the seed trade in the introduction of improved varieties of both swedes and common turnips. Several of these new varieties show marked improvement over most of the older sorts, alike in yield per acre, quality, and keeping properties.

Produce of different Varieties. —

Experiments purposely conducted to test the point, and general experience in turnip culture, have shown clearly that there is a very wide range in the productive powers, not only of the various kinds of roots, but also of each individual variety, propagated and grown under different conditions. In the midland and southern counties of England the crop of swedes generally runs from 12 to 18 tons per acre; in Scotland, Ireland, and north of England, from 18 to 30 tons. Common turnips may give from 1 to 4 or 5 tons more per acre. Often, indeed, the extremes are still greater.

Much of course depends upon soil and climatic conditions, which are beyond the control of the farmer, and still more perhaps upon the system of culture, which is almost entirely within his direction; yet it is unquestionable that, by selecting sorts which have been distinguished for abundant production upon the different classes of soils, the yield of the crop may be sensibly increased. In regard to the feeding and keeping properties of roots the same remark holds good. With turnips, as with all farm plants and animals, the selection of the sorts best adapted for the surrounding conditions and the purposes in view is a point which demands, and will repay, the most careful attention from the farmer. Indeed it is a point which the farmer who would be successful cannot afford to overlook or disregard.

Climatic Influences on Turnips.—The turnip has a moderate range of temperature. A summer isotherm of about 56°, with a moderately moist atmosphere, is the most favourable. Before getting into the rough-leaf stage, it is easily adversely affected with night frosts. These, with hot scorching days, such as are frequently experienced in the end of May and first half of June, are very inimical to the young turnip in its cotyledon stage, and often cause its destruction, and necessitate resowing.

Insect Attacks.—This condition is generally aggravated by the attacks of insects that puncture and nibble at the seed-leaves, which injury in dry weather tends to kill the plant from bleeding or drying up. But insects seldom do much harm at this stage if the weather should be damp and the nights free from frosts.

Proportion of Leaf and Root.—Regarding the question of the proportion of top to root, interesting experiments were conducted at Rothamsted. It was found that common turnips yield a much higher proportion of leaf to root than swedes; and if the leaf be unduly developed, there may even be more nitrogen, and more total mineral matter, remaining in the leaf to serve only as manure again, than accumulated in the root to be used as food. In the case of swedes, however, not only is the proportion of leaf to root very much less under equal conditions of growth, but the amount of dry matter, of nitrogen, and of mineral matter, remaining in the leaf, is very much less than in the root. In one case, with a highly nitrogenous manure, whilst there was, with an average of 10¼ tons of white turnip root, nearly 6¼ tons of leaves, there was with swedes, with more than 12 tons of roots, not quite 1 ton of leaf. In a series of experiments, moreover, with different manures, whilst white turnips gave from 300 to 600 parts of leaf to 1000 of root, the highest proportion by weight of leaf to root in the case of swedes was 78½ to 1000. Whilst in yellow or white turnips a very large amount of the matter grown is accumulated in the leaf which is not always consumed as food, in swedes a comparatively small amount of the produce is useless as food for stock. Generally the proportion of top to root in swedes may be stated at from 10 to 14 per cent, and in common turnips from 16 to 20 per cent.

Order of Using Turnips.—White varieties come earliest into use, and will always be esteemed on account of their rapid growth and early maturity; and though unable to withstand severe frost, their abundance of leaf serves greatly to protect the roots from the effects of cold. Being ready for use as soon as pasture fails, they afford the earliest support to both cattle and sheep.

Yellows then follow, and usually last for about two or three months. Swedes come into use after yellows, and with care may be in good condition for consumption till the month of June.

Ill-shaped Turnips.—In *a*, fig. 601, is shown an ill-formed turnip, as also one, *b*, which stands so much out of the

ground, represented by the dotted line, as to be liable to injury from frost. The turnip *a* is ill formed, inasmuch as the part around the top is hollow, where rain or snow may lodge, and find its way into the heart, and corrupt it.

Number of Turnips per Acre.—It may be useful to give a tabular view of the number of turnips there should be on an imperial acre at given distances between the drills, and between the plants in the drills, and of the weight of the crop at specified weights of each turnip, to compare actual receipts with defined data, and to ascertain whether differences in the crop arise from deficiency of weight in the turnip itself, or in the plants being too much thinned out. The distance between the drills is the usual 27 inches; the distances between the plants as stated. As the imperial acre contains 6,272,640 square inches, it is easy to calculate what the crop should be at wider and narrower intervals between the drills:—

Width of drills.	Distances between the plants.	Area occupied by each plant.	Number of turnips there should be per imperial acre.	Weight of each turnip.	Weight which the crop should be per imperial acre.
Inches.	Inches.	Square inches.		lb.	tons. cwt.
27	9 between the plants of white turnips.	243	25,813	1	11 10½
				2	23 1
				3	34 11½
				4	46 2
				5	57 12½
				6	69 3
				7	80 13½
				8	92 4
27	10 between the plants of yellow turnips.	270	23,232	1	10 7
				2	20 14
				3	31 1
				4	41 8
				5	51 15
				6	62 2
				7	72 9
				8	82 16
27	11	297	21,120	1	9 8
				2	18 18½
				3	28 5
				4	37 14½
				5	47 2
				6	55 11½
				7	65 19
				8	75 8½

Careful and Careless Thinning of Roots.—A close inspection of these figures enables one to realise how important careful thinning is, and how serious may be the loss from carelessness in this operation. For example, 5-lb. turnips, at 9 inches asunder, give a crop of 57 tons 12½ cwt.; whereas

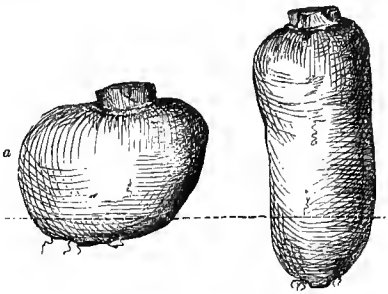


Fig. 601.—*Ill-shaped turnip.* *Tankard turnip.*

the same weight of turnip at 11 inches apart gives only a little more than 47 tons. Every farmer knows how easy it is for careless workers to thin out the plants to 11 instead of 9 inches, and yet, by so doing, 10½ tons of turnips per acre are sacrificed. The figures as to weight are also worth looking at. A difference of only 1 lb. on the turnip—from 5 lb. to 4 lb.—at 9 inches asunder, makes a difference of 11½ tons per acre.

Specific Gravity of Turnips.—All turnips, except swedes, are lighter than water. This is remarkable, because all the ingredients composing turnips—sugar, gum, proteine compounds, fibre, &c.—are heavier than water: the conclusion is, that all turnips contain a larger proportion of air than swedes.

Distribution of the Turnip.—The turnip is a plant whose constitution is eminently suited to the damp and comparatively cold climate of the British Isles. The crop indeed reaches its most certain and highest development in the northern parts of the islands and in the moist climate of Ireland. The cool climate of Caithness, Orkney, and even Shetland favours its bulb growth. In the Hebrides it grows well, the damp air causing increased luxuriance of top.

In the south of England the turnip is often a failure in dry seasons. The hot dry winds occasionally experienced

there are liable to kill the plants in the early stages, and to cause stunting, and sometimes mildew, if the growth is farther advanced. There, in some seasons the plant has a struggle for days and weeks with dry warm winds and a parched soil, and makes little progress until the shorter days and cool nights of autumn set in.

The turnip thrives in a temperature too cold for the profitable cultivation of cabbage, kohl-rabi, or mangels. These in the British Islands do best in moderately dry warm seasons. The oat luxuriates in a climate similar to what is required for the growth of turnips, and wherever heavy, well-filled oats can be grown, there the cultivation of the turnip will succeed.

Soils for Turnips.—The soils most suitable for turnip cultivation are those of a light friable description. The fine state of division to which these can be readily reduced favours the germination of the small seeds. On such soils cultivation is easy, and they also suit the habits of the plant, which spreads its roots like a network into every part of the soil. Alluvial and sandy soils are of all the best for the turnip plant. Next come the lighter soils formed from trap or volcanic rocks, and the lighter soils resting on Silurian, Cambrian, Devonian, granitic, and New Red Sandstone rocks.

Clay Soils Unsuitable for Turnips.—The soils least suitable are the clays, from whatever derived. The London, Oxford, and Kimmeridge clays being especially stiff, are not well suited for turnip cultivation, partly from the great difficulty in securing a braird among the rough particles in dry seasons, from the hardness of such soils preventing the free spreading of the roots, and from the absorbed and retained water injuring the roots in wet seasons. On the stiffer clays, which occupy a large area in the southern part of England, the cultivation of the crop is so precarious that it cannot be profitable in the average of seasons, although good crops are occasionally grown. Were it not that the working of the land for the crop acts upon the soil similarly to a bare fallow, its cultivation on these soils would not be attempted to any considerable extent.

TILLAGE OF LAND FOR TURNIPS.

Variety of Systems.—The system of tilling land so as to prepare it for the turnip crop necessarily varies greatly upon different classes of soils, and in the different parts of the country. The condition of the land as to foulness or freedom from weeds has likewise to be considered in deciding upon the system of tillage likely to be most effective and economical.

It has also to be remembered that in many farming operations there are variations in local customs, for which there is no apparent or sufficient explanation beyond the simple influence of long-continued usage. In regard to most branches of farm-work, it is assuredly true that there are several ways of doing the same thing,—several methods by which the same piece of work may be accomplished, and this, too, with almost equal efficiency, and with little difference in outlay.

That teaching which would seek to inculcate the idea that any one way is *the* right way and the *best* way, and all other methods wrong or inferior, is essentially narrow and unsafe, arising most likely from limited experience or a dogmatic spirit—or from both; for there is a close kinship between dogmatism and limited knowledge. The more one sees of the detail-work of farming in the various divisions of our own country and in foreign lands, the less inclined one is to dogmatise,—the more indeed is one impressed with the almost infinite variety of methods and practices which farmers may, with prudence and good results, pursue in the prosecution of their calling.

The introduction of these remarks at this particular point has been suggested by the fact that in his observations as to the methods of root culture in nearly every corner of the British Isles, and in foreign countries as well, the editor of this work has noted with special interest the almost endless variety in the details of practice. In perusing the remarks which follow as to the system of preparing turnip land, and in contrasting the practices described and recommended with different practices which may prevail in certain localities, it should there-

fore be borne in mind that it is not presumed that the methods described here are the only methods worthy of description and commendation. Indeed one may go further, and suggest that any farmer who has been moderately successful with methods different from those described here should think well before introducing a change, doing so at first only to a small extent, and in an experimental way. To describe all the good systems of root culture is out of the question. The details set forth here are those of certain methods known to be pursued with success in different parts of the country.

Soil, Climate, and System of Tillage.—The character and condition of the soil are of course the main considerations in determining the system of tillage. Stiff clay land requires very different treatment from light friable soil. The former must not be touched in wet weather, or while it is in a very wet condition. The latter is much less liable to injury from unseasonable working.

The climate is also answerable for variations in systems of tillage. The comparatively mild open winter of the southern and lower-lying parts favours autumn and winter tillage. In the higher-lying and colder districts, with their severer winter, much of the tillage work must be delayed till spring.

Prevailing System.—The system which prevails most largely in the principal turnip-growing district of this country is to plough the land with a strong furrow in the autumn or winter, allow it to lie in this condition under the disintegrating influences of winter, and in spring clear it of weeds and reduce it to the desired condition for the reception of the manure and the seed. Unless the land happen to be exceptionally foul, or is of a strong clayey nature—in which cases other methods to be explained presently may be adopted—this system of autumn or winter ploughing and spring cleaning and manuring answers admirably for the turnip crop.

Normal Conditions.

In the first place, there is described the process of preparing land for turnips, under what may for convenience be called *average or normal conditions.* By this term is meant land well, or at least moderately well, suited for turnips—heavy clays excluded; in average condition as to weeds, fertility, and drainage, and with average weather.

Exceptional circumstances will receive treatment subsequently.

Autumn and Winter Ploughing.—Turnips almost invariably follow a grain crop. As soon as practicable after the completion of the grain harvest, the stubble land intended for roots next year is—unless very foul—ploughed with a deep strong furrow, varying in depth according to the character and depth of the total surface-soil from perhaps 10 to 14 inches—rarely over 12 inches. In deep ploughing care has to be taken not to bring to the surface more than a very small quantity (if any) of the subsoil at one time. Many subsoils contain matter which is positively injurious to vegetation, and which, if mixed freely with the surface-soil, may for a considerable time have a deleterious influence on the crops. If the land be strong loam, it may be advisable to yoke three horses in the plough. When the land is very steep, and it is desired to run the furrow up and down the incline, the plan of going up-hill empty and taking a strong furrow down-hill is often resorted to. With this method no feerings are required after the first side furrow, as all the ploughs follow each other at convenient intervals in the one furrow.

A good deal of time, however, is unavoidably wasted by this plan, and farmers generally contrive to get a furrow each way by running the plough so as to avoid the direct line of the incline. For ploughing with a strong furrow in steep land, the one-way ploughs described and illustrated in vol. i. pp. 372, 373 are very useful. With the one-way plough the furrow can always be thrown down-hill, which of course lightens draught greatly.

In this strong furrow the land lies over winter, deriving much benefit from the frost and snow to which it is thus freely exposed.

Spring Tillage.—In average seasons the land intended for turnips, which has been ploughed in autumn or winter as just described, may probably not be touched again until the sowing of the

grain crops has been completed. The spring working of the turnip land is usually begun in April, but the greater portion of it will most likely have to be gone through in May, some of it perhaps even later.

The extent and nature of the spring tillage will depend upon the character and condition of the land and the state of the weather. For even in what may still be called normal or average conditions, there are many variations which demand the careful consideration of the farmer.

Ploughing or Grubbing. — Most likely one spring ploughing will be sufficient, this time with a moderate furrow, perhaps from 6 to 9 inches deep. Many farmers now prefer to stir the land with some kind of strong iron-toothed implement of the grubber kind; or it may be a half-plough, half-grubber, usually spoken of as a digger.

Whether it is advisable to plough the land, or only to drag it with a grubber, cultivator, or digger, will depend upon the kind of soil and the weather at the time. If the subsoil is very hard, the plough will be the best for breaking it up. Again, if the season is wet, the plough is preferred by many, in the belief that less injury is inflicted by the treading of the horses in ploughing, unless the grubbing is done by steam-power, which is very effective if not done too deeply.

The cultivator gets over the land much more quickly than the plough. But if the soil is stiff or full of weeds, a second turn after harrowing and gathering will be necessary. By the use of the cultivator the fine surface-mould produced by the winter frosts will be kept nearer the surface, and will make the germination of the turnip seed more certain. In stiff soils fewer of the large clods will be brought to the surface; in dry weather less evaporation from the surface will take place, and the success of the crop will be more assured.

Some of the modern diggers are admirably adapted for their work. Used on stubble land the digger pulverises the soil to a good depth, and turns only the upper few inches, thus exposing the roots of weeds which lie near the surface to the winter's frost, and leaving the soil thoroughly broken up. This also facilitates the removing of surface weeds from the land. Amongst land after turnips it also does good work. While pulverising the soil it does not turn it over, and expose the dung, as is often done by the common plough.

The Tennant grubber (Hunter) is shown in fig. 602; Clay's grubber in fig. 603;

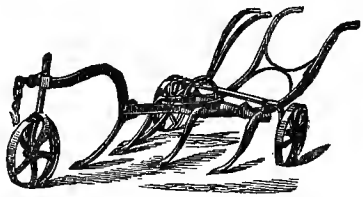


Fig. 602.—*The Tennant grubber.*

and Martin's spring-tined cultivator in fig. 604.

Pulverising Ploughs. — By the attachment of revolving prongs, ploughs are made which, at the one operation, plough the land and pulverise it, throwing most of the weeds on to the surface.

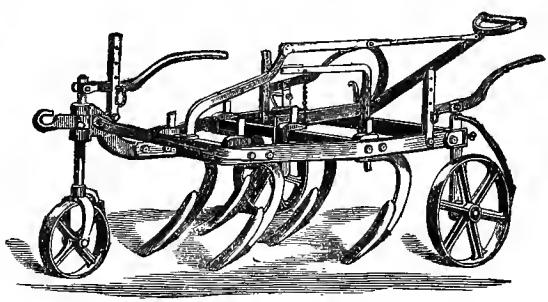


Fig. 603.—*Clay's grubber.*

Harrowing Turnip Land.—Whether ploughed or stirred, the land must be afterwards harrowed, the weeds picked off, and the large stones, if any, gathered. If the weather permit, harrowing and rolling must be continued until the clods are reduced, and a fine mould formed.

Removing Weeds.—The harrowing brings the weeds loosely to the surface. Chain-harrows are frequently used to collect the weeds into heaps, and so are horse-rakes, the work being concluded

by hand-rakes and forks, or graips. Hand-picking is preferred by many farmers, and is of course the most thorough system. The weeds may be burned in heaps on the field and the ashes scattered around, or carted to some convenient corner to be united with lime to form a compost-heap. In the latter case care must

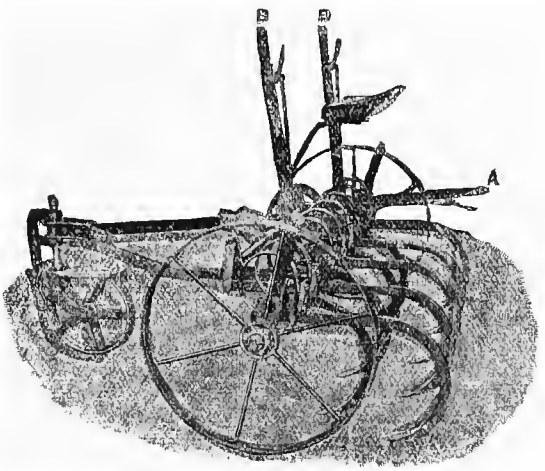


Fig. 604.—*Martin's cultivator.*

be taken not to spread the compost on the land until the vegetable matter in it has been thoroughly decomposed.

Exceptional Conditions.

In soils well suited to turnips, and kept in good heart and condition as to cleanliness, the foregoing process of tilling and cleaning will most likely be sufficient to prepare the land for the sowing or laying down of turnips, as it is often termed.

But there are many circumstances which render deviations from the prevailing system necessary or advisable. For instance, stiff clayey land, land which is excessively foul, and land unusually free from weeds, all receive peculiar methods of treatment. Again, the land may be both stiff and foul, and in this case still another plan will be adopted. The questions as to whether the roots are to be sown in drills or on the flat, and at what time the farmyard dung is to be applied—whether in the autumn or winter, on the flat in spring, or in drills at sowing-time—are also responsible for variations in the preparatory work.

Preparing Foul Clay Land.

This is often a serious undertaking. No progress can be made with it in wet weather. Indeed, any attempt to cultivate or clean clay land when it is in a wet condition must inevitably result in failure. Far better let men and horses remain idle than allow them to work stiff clayey land unseasonably. In this condition the more it is worked the greater is the injury inflicted.

When, therefore, the farmer has before him the unenviable task of having to clean stiff clay land which is in very foul condition, he must watch the weather carefully and seize every suitable day for the purpose.

Autumn Cleaning.—For cleaning land of this kind the autumn is the best time — that is, if the weather should be favourable. Begin the work as soon as the grain crops are secured. The first operation will either be the cultivating (or grubbing) or the ploughing of the land with a shallow furrow,—a furrow just deep enough to turn over, but *not to bury*, the weeds. The depth of the first furrow is indeed regulated mainly by the character of the weeds, whether they are deep-rooted, creeping, or surface weeds. Some of the surface weeds may be killed by being buried with a deep furrow; but couch-grass, docks, thistle, knapweed, and other well-known troublesome weeds, require more drastic treatment. Grubbing or dragging and harrowing follow ploughing, and if necessary to break clods holding weeds, the land is then rolled, again harrowed, and the weeds collected and burned or carted away.

A Second Crop of Weeds.—An examination of the land may reveal the fact that it is still far from clean. In this case the whole process should, if the weather permit, be at once again gone over. The ploughing may perhaps be omitted. The grubber or cultivator, fol-

lowed by the harrows, will take the remaining weeds to the surface, and this time, in particular, it will be advisable to hand-pick the weeds, so as to ensure that all the little particles of couch-grass roots may be removed.

Do not Break Weeds. — Excessive tillage is liable to break these weed-roots into small pieces, each of which, if left, will form a centre of filth. It is therefore important to have the weeds brought to the surface with as little knocking about as possible.

Cross-cultivation.—The subsequent ploughing and grubbing are usually given at right angles to or in a slightly different line from the preceding. The object of this cross-cultivation is of course to ensure that all portions of the soil may be stirred.

Steam-power for Cleaning Clay Land.—For the cultivating and cleaning of strong land steam-power is very suitable. The steam-cultivators go over the ground quickly, and they can be as easily regulated as to depth as implements for horse-labour.

Half-ploughing.—Land which is *excessively foul* is sometimes cleaned by another process, — a piecemeal method known as break-furrowing, raftering, or half-ploughing. Only half the surface is at once disturbed, each furrow being thrown on to its own breadth of ploughed land. Harrowing and weed-collecting follow, and this fleece of weeds being removed, the strips of the land formerly undisturbed are then turned over by the plough, harrowing and weed-collecting completing the process. This is a tedious and costly process, which is not often adopted, and need not be resorted to except in such rare cases as where the land is so excessively foul that the entire mass of weeds in it could not be conveniently dealt with at one time.

This system is more frequently adopted for the purpose of killing surface-weeds. In this case the land lies over winter in the ridged-up appearance which the half-ploughing gives to it.

Autumn Dunging and Ploughing. —Assuming that the weather has been sufficiently dry and free from frost to enable the farmer to complete in autumn and early winter the cleaning processes described above, the next step—with strong land intended for roots—will perhaps be to spread its allowance of farmyard dung and plough in this with a shallow furrow. This is the usual practice, and by far the best plan in stiff land of this kind, where the turnips are to be sown on the flat, and where there is a sufficient supply of dung ready in time for application before the last ploughing in autumn or early winter. The advantages of the autumn instead of the spring dunging of heavy land will be mentioned in dealing with the manuring of turnips. If the dung is not to be applied at this time, the land is turned over in a strong furrow before the rigours of winter fairly set in.

Spring Tillage of Strong Land.— The spring tillage of stiff clays intended for roots has to be carried out with the utmost care and caution. Clay is stubborn material, in the working of which the farmer, who has not before had practical experience of it, is liable to unwittingly commit errors, which may seem trifling at the time, but which may result in serious injury to the crop.

If the land has been cleaned and dunged in the autumn, the spring work is thereby greatly simplified. Lying over winter in a strong furrow, the land becomes pulverised and more easily prepared for the seed. In southern parts, where the winters are open, the spring tillage of this land is begun as early as possible—as early as January or February if the weather is sufficiently dry. It is then cross-ploughed at least once. Often, indeed, strong land is ploughed two or three times in spring, in the attempt to reduce it to that fine tilth which is so advantageous to the root-crop.

Grubbing or Cultivating in Spring. — Grubbing or cultivating is preferable to repeated ploughing in spring, for while the former leaves the finely pulverised soil on the surface, the plough turns this underneath. An excellent implement for this purpose is the modern cultivator, such as that in fig. 604, which has spring tines set in such a manner as to enter the hardest soil.

By repeated harrowing, rolling, and grubbing or dragging, the rough strong land is reduced as finely as possible, and is thus prepared for the reception of the seed.

Preparing Clean Land.

When the land intended for turnips is in a cleanly condition, the preparatory tillage operations may be considerably lessened. As early as possible in the autumn or winter, the land, whether light or strong, is ploughed with a deep furrow or cultivated with a rank grubber. On strong clay land the dung—as much of it as is then made—is spread on the stubble just before ploughing.

In spring, strong clean land will require similar treatment to that just described in speaking of the preparation of foul clay land, which had been cleaned in the autumn.

Spring Tillage of Light Clean Land.—But in the case of light land free from weeds, very little spring tillage may suffice. Indeed, such land may be allowed to lie in the winter furrow till the work of grain sowing is finished. It may then receive a strip of the harrows across the winter furrow, be turned over once with the plough, or stirred by the grubber or cultivator, and again harrowed two or three times. In many cases this will be found sufficient; but if the tilth is not reduced as finely as desired, another turn of the grubber or cultivator and harrows may be prescribed, and with this the preparation will be completed. Where injury from lack of moisture is feared, early harrowing to check evaporation is sometimes resorted to.

Overworking Injurious.—Not unfrequently injury is inflicted upon the turnip crop by the overworking of the land in spring. Turnips delight in a fine moist soil. The finer the soil is the better, but it must also be damp. In preparing turnip land, therefore, the farmer must strive not only to break down the soil but also keep in the moisture. This, as will be at once understood, is not so easy to accomplish. Repeated ploughing and opening up the land, late in spring and early in summer, encourages the escape of moisture. It is thus important that in dry districts the deep turning and stirring of the land should be done in autumn, winter, and early in spring, so that when the dry season has set in, shallow stirring and surface-scratching may be sufficient to provide the desired tilth.

The dissipation of moisture during spring may be to some extent lessened by immediately following the ploughing or grubbing by harrowing.

Even in moderately moist climates this matter is deserving of more attention than farmers, as a rule, bestow upon it. Indeed it may be described as one of the cardinal points in successful turnip culture. The importance of retaining moist soil around the young turnip plant is perhaps the consideration which has been most powerful in maintaining the system of growing turnips on the flat in England.

Forking out Weeds.—A practice much pursued in England, with land not so foul as to require a special course of tillage to clean, is to send several workers over the stubbles in the autumn with graips or forks to dig out couch and other visible weeds. This is a good plan, likely to save after-labour in removing weeds.

It is the habit, indeed, of some particularly careful farmers, to send two or three labourers over the entire farm in this way, forking out any weeds to be seen, and giving special attention to headridges and sides of fences, which often form perfect nurseries for weeds.

Turnips on very Strong Clays.—In some cases in England, on very strong clays, which are by nature ill adapted for turnip culture, crops of swedes, which would delight the heart of any farmer, are occasionally grown. The main secret of success, in these instances, has nearly always been the studied and careful preparation of the land. Such deep tillage and cleaning as the land receives are done in dry weather in autumn, when the dung is also put in. Then in some cases which we have known to be successful in an eminent degree, no further stirring of any kind is given to the soil till sowing-time, when, after a turn of the harrows, the seed is sown in rows on the flat.

This plan, of course, would not succeed in land containing many weeds; but on some of the strongest clays in England we have seen it carried out with the most gratifying results—upon land so strongly adhesive that it would sometimes exhibit in spring with little effacement the footprints made upon it by labourers five months before.

The chief difficulty in turnip culture, on strong clay land in a dry climate, is to obtain a strong regular plant. This is most effectually promoted by retaining the winter moisture in the soil. And the best method of conserving the moisture is to clean, dung, and plough the land in autumn, and stir it as slightly as possible after the advent of warm weather in the following season.

Still, when the farmer has done his very best, turnip growing upon very strong clayey land will often fail. And while it is interesting and may be useful to record these instances of exceptional success, one cannot with confidence recommend the extensive culture of turnips upon such land.

SOWING TURNIPS.

In the early days of turnip growing in this country the seed was sown broadcast on the flat surface of the land. At one time, indeed, that was the universal custom with all farm crops.

Introduction of Drill Sowing.—For the introduction of that most serviceable system of drill sowing we are indebted to Jethro Tull, whose writings, during the first generation of the eighteenth century, did much to promote the improvement of farm practice. In his book on *Horse-hoeing Husbandry*, published in 1731, he advocated the system of drill-sowing wheat in narrow ridges. The success of the method attracted much attention, and it was soon after tried for other crops. For turnips it was found specially suitable, and as early as 1745 the drilling of turnips was practised in Dumfriesshire by Mr Craig of Abbeyland. The system rapidly won many converts, and soon after the middle of the eighteenth century, turnip culture in drills or rows was being pursued successfully in various parts of the country—notably, besides Dumfriesshire, in Cumberland, Northumberland, Roxburgh, Berwick, and Norfolk. Indeed, to the last-named county, still noted for turnip culture, an improved system of turnip cultivation was as early as 1730 introduced from the Netherlands by Charles, Viscount Townshend of Rainham.

Turnips in Raised Drills.—In Scotland, Ireland, and the north of England, turnips are now almost universally grown in raised drills. This method, it is said, dates from about 1760, when it was begun by Mr Dawson of Harperton, Kelso. For districts with a moist or moderately moist climate, it has long ago proved itself to be superior to all other methods of root culture.

Disadvantage of Raised Drills.—The one drawback to raised drills is that throwing up the land in this form encourages evaporation, and thus intensifies the effects of drought. Mainly for this reason, the system of sowing in rows on the flat is preferred in the greater part of England.

Advantages of Raised Drills.—The system of raised drills possesses several advantages of the highest importance. In the first place, the gathering of the finely pulverised soil together in the raised drill gives the roots the benefit of a deeper and freer soil than they would obtain on the same soil in the flat system. The stores of plant-food in the surface-soil, and the manure applied at the time, are brought into closer proximity to the young plants, whose growth in the early and most critical stages is thus effectually stimulated. The thinning and hand-hoeing of the crop are more easily and expeditiously accomplished in the raised drill than on the level surface, while the subsequent hand-hoeing and horse-hoeing, or drill harrowing, bring back the land to a nearly level condition by the time the crop is throwing out its spreading root-fibres.

Width of Drills.—This varies from 24 to 30 inches, the most general width being 27 inches. In narrow drills there is difficulty in covering rank dung thoroughly, and there is less facility for horse-hoeing. On the other hand, the yield of the crop per acre will be lessened by having the drills much wider than about 27 inches.

Drill-plough.—The raised drills are now most generally made by the drill-plough, the construction of which is well shown in fig. 580. The breast and mould-boards of this, as of all other improved drill-ploughs, are formed so as to throw up the soil loosely rather than to squeeze it together, as would be done by a wedge-shaped plough. The width of

the drill can be easily regulated by the screw shown between the shafts. The "marker" is adjusted to the corresponding width, and with these improved ploughs a skilful ploughman makes drills that are pleasing to the eye of a tasteful farmer—straight in line, and uniform in depth and width.

The *depth* of the drill must be sufficient to thoroughly cover the dung. Where there is no dung to cover, the drill may be shallower, yet deep enough to make the ridge complete on the top.

In many districts the drilling is done by the ordinary single plough. In drilling with the single plough, the tail of it is purposely kept high, which leaves the bottom of the drill narrow. One passage of the plough is quite sufficient for either opening or closing, and many consider it preferable to the double mould-board plough, unless for earthing up potatoes. One point in favour of the single plough for drilling is, that by it the clods are thrown over the drill and fall into the bottom of the previous furrow, instead of being thrown, as by the drill-plough, into the centre of the drill, above the dung and under the seed.

Raised Drills on Strong Clays.—The system of raised drills is not so suitable for strong adhesive clays as for more friable soils. Still, even in very stiff land it is often practised with success. On land of this kind—which, as we have seen, may be seriously injured by much tillage late in spring—perhaps the best plan is to form the drills in autumn or winter, after the land has been cleaned, dunged, and ploughed. In these open drills the land lies till the time of sowing, when a light harrow, chain-harrow preferably, is drawn over the land in the direction of the drills. Any artificial manure to be given is then sown broadcast, the drills are set up by the drill-plough, and the seed at once sown.

This provides a moderately fine tilth for the seed on the top of the drill, and yet it does not unduly promote evaporation. But it leaves the soil hard a few inches below the surface, sometimes checking slightly the development of the crop.

Drilling on the Flat.—In the midland and southern counties of England, the prevailing system is to sow the turnip seed on the flat surface in rows from 15 to 22 inches apart. As already explained, the main object in pursuing this plan is to avoid the dissipation of moisture, which is to a considerable extent unavoidable in raising the soil into loose ridges.

As a sort of general rule, it is recommended that, in districts with an average rainfall of less than 24 inches per annum, the flat system should be the prevailing one. A maximum crop is not likely to be obtained by this method, but in dry climates it is the safest, and is therefore extensively pursued in the south.

Width of Rows.—The rows on the flat are invariably narrower than raised drills. The most general width between the flat rows is from 18 to 20 inches, occasionally more and frequently less. With a greater width in the midland and southern counties of England, where the roots seldom attain the weights that are common farther north and in Ireland, the crop would fall off in yield per acre; yet it will be readily understood that the comparatively little space thus left between the rows on the flat does not permit of satisfactory horse-hoeing while the plants are growing. Moreover, the horse-hoeing cannot be begun so soon — not until the plants are sufficiently far up to ensure that they may not be unwittingly buried.

Broadcast Sowing of Turnips.—The broadcast sowing of turnips is now rarely practised. Where turnips are grown for the development of root it is quite unsuitable.

Still, in certain cases, when a crop of turnips cannot be got in in time to grow roots satisfactorily, a useful supply of green food in spring may be provided, only in a good climate of course, by sowing in August, with the broadcast barrow, from 1¼ to 2 lb. per acre of turnip seed. For this purpose the ground is harrowed before and after sowing, and then rolled (vol. i. pp. 341, 342).

When not to be systematically thinned, turnips do better sown broadcast than in rows.

In some parts of the south, where an abundant supply of field food for sheep is a matter of great importance, land planted with beans is occasionally thinly broadcasted with turnip seed. In a mild

autumn, after the harvesting of the beans, the turnips develop a wonderful bulk of very useful food.

The actual details of the process of sowing turnips depend upon whether the raised-drill or flat-row system is pursued, and what manure has to be applied at the time of sowing.

Dunging and Sowing in Raised Drills.

Taking first the system which prevails in Scotland, Ireland, and the northern counties of England, it is found that the detail work of sowing — assuming the land to be already cleaned of weeds, and sufficiently pulverised—consists, in succession, of opening the drills with the drill-plough, carting the dung and spreading it in the drills, perhaps drawing a light harrow along the drills, sowing artificial manures most likely broadcast, covering in the drills with the drill-plough, and sowing the seed with the drill-sower.

Simultaneous Drilling and Sowing.—Upon large holdings possessed of a sufficient force of horse and manual labour, all these processes go on at one time. The result in the crop is generally most satisfactory when there is no appreciable delay between the opening of the drills and the completion of the operation by the sowing of the seed. It is bad practice to open many more drills in one day than can be manured, closed, and sown before nightfall of the same day.

Stale Seed-bed Undesirable.—Turnip seed does not take kindly to a "stale" seed-bed. It comes away most satisfactorily when sown upon a freshly turned-up mould, fine in the texture, and tolerably moist — about two to four hours after the drills are closed in. When, therefore, it does happen that a portion of land has lain for a few days in finished drills unsown, perhaps on account of wet weather, some farmers consider it advisable to draw a light harrow along the drills, and set them up afresh with the drill-plough. This, however, takes time and labour when these can ill be spared, and unless the surface of the drills has become firmly packed or caked by heavy rains, the harrowing down and drilling up again may be dispensed with.

The Force Employed.—The arrangement of the force of horses and workers in sowing turnips on a large farm, so that there may be no delay and no collisions or interruptions to any of the force, requires considerable skill and forethought. We will assume that there are two drill-ploughs at work, and that the force for carting and spreading dung and sowing manure will be sufficient to keep these fully employed opening and closing drills during the entire day. The number of carts, and men to fill them, required to keep the two drill-ploughs busy, will depend upon the proximity of the dung-heap to the drills, and the quantity of dung to be applied per acre. With the dung in heaps on or near the field, and not more than about 15 tons of dung per acre, four carts, with one or two men to assist the carters in filling, should be amply sufficient. Assuming that the two drill-ploughs would open and close about four acres per day, the four carts would thus convey to the drills about 60 tons of dung per day, perhaps from 18 to 20 loads each, in the full working day of ten hours.

Four or five workers — men, lads, or women—will be required to spread the dung, one man will sow the artificial manure, and another will follow all with the two-drill turnip-sower, drawn, perhaps, by a good-sized cob or farmer's pony. The steward, bailiff, or grieve (as the farm manager is variously called), or the farmer himself, usually sows the turnip seed, and as the turnip-drill takes two drills at a time, and the draught is very light, it will usually go over the whole day's opening and closing in rather less than a half-day. There will thus be employed in the "laying down" of about four acres of turnips eight horses, at least eight or nine men, and five or six lads and women for a whole day, and an additional man and horse for four or five hours. The cost, per acre, involved by the employment of this force would vary with the rate of wages, price of horses, and cost of horses' food in different districts and seasons.

Arranging the Force. — So as to avoid interruptions and ensure the maximum amount of work done in an efficient and satisfactory manner, it is important to have the duties of each person clearly and intelligently defined and understood

beforehand. About a dozen drills or so should be opened the night before, so that the full force may at once get to work in the morning.

Opening and Closing Drills.—As to the two teams with the drill-ploughs, the better plan is for the one to open and the other to close in the drills. In some cases the practice is for the two ploughs to follow each other, and open in the one direction and close in the other.

In cases where there is only one drill-plough at work, the best plan is to open in the one direction and close in the other. This plan is followed where the single plough is used to open and close the drill with one furrow.

Another Method.—The following is another method of arranging the force, which some would prefer. In the evening before, 20 drills or so are opened, so that an immediate start may be made with the dunging operations in the morning. Three ploughs being used, they open the drills up-hill, and close them down the slope, if the field is not level. Three persons are placed at the dung-heap to load the four carts employed in dragging the dung. Each man throws the dung out of his own pair of carts, which come to the drills in rotation. This plan gives an interval of leisure to each man, so that he is not constantly kept in one position. A boy is sometimes employed in driving the carts between the dung-heap and the drills. When the first drill receives its dung, 4 spreaders are placed in divisions of equal length along the drill. This enables the manager to check the work of any spreader, which can be readily known. A machine for sowing manure, and another for sowing turnips, complete the operations. There is no waiting in any division of the work, but the whole proceeds in a regular manner. In this way 12 horses, and 15 men, women, and boys, can lay down from 6 to 8 acres of turnips per day without any undue pressure.

Turnip Seed Drill. — Various have been the forms of turnip-sowing machines, and modes of distributing the seed. The old heavy square wooden-framed machine with its revolving seed-barrel, once so common, is now seldom seen. Its weight was useful in heavy soils, but it was cumbrous, and the seed-barrel required great care to give an equal delivery. The improved modern turnip-drill sowing-machine is light, elegant, and easily managed. It consists of a simple iron frame, with shafts, handles, two rollers, seed-boxes, spouts, and coulters. The arrangements for working the seed-boxes, and for regulating the quantity of seed deposited, vary considerably, but the better known drills are all thoroughly efficient and reliable in working. The general formation of the modern turnip-drill is shown in fig. 605, which represents an excellent machine, made by James Gordon, Castle Douglas. Most of these modern drills can also be arranged with larger boxes for the sowing of mangels. Rollers can be attached to the rear of the machine, but these are only sometimes used.

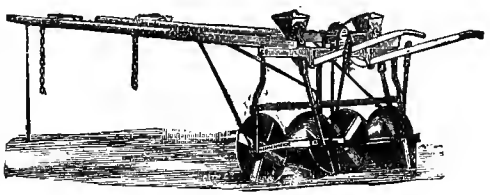


Fig. 605.—*Turnip drill-sower.*

Drilling Manure and Seed.—Manures are occasionally drilled along with the seed. In the raised drill system this is not often practised, as it is tedious and not of much practical advantage over broadcasting, unless where very small quantities are used. When large quantities of manures are used, they should be distributed over and mixed through the soil.

Water Drill. — The water drill, so common in the flat-sowing system of England, has been used with advantage in the north in dry seasons. It will sometimes secure a braird which would otherwise have failed. A stream of water, in which superphosphate may be dissolved, is run into the seed-rut. It acts as a moistener of the soil, and stimulant to the young plants.

Consolidating the Drill-top.—If the weather is very dry and the soil open, it is found advantageous to go over the drills a second time with the turnip machine, although no seed is sown. The

rollers consolidate the drills, and make a braird more certain. A drill-roller such as that shown in fig. 584 is admirably suited for this purpose.

The braird seldom comes well if the soil is so damp that the rollers clog with earth.

Drill for Sowing on the Flat.—A machine of a different description is employed for sowing turnip seed in rows on the flat surface. It is in general form similar to the Suffolk drill, shown in fig. 421, vol. ii. p. 124, but is provided with means for sowing either dry artificial manure or water or liquid manure along with the turnip seed.

Water and Dry Drills compared.—Both the water and the dry drills are used in the south of England. There is much difference of opinion as to their respective advantages and disadvantages. By the use of the water drill, the seed of course is provided with more moisture in the seed-bed. In average seasons this would most likely be an advantage, yet it is maintained by many that it may often prove to be the reverse, or at any rate a doubtful advantage. In very dry seasons, for instance, it has been found in numerous cases that a stronger and more regular plant has been obtained from the dry drill than from the water drill. The reason assigned for this is that the superabundance of moisture at the very outset caused the seeds to germinate too rapidly, and set up a rate of growth which could not be maintained when the artificial supply of moisture began to fail.

Manure Injuring Seeds.—One important drawback to the system of applying artificial manures in close contact with the seed, is that the vitality of the seed is thereby apt to be injured or destroyed. An obvious remedy for this is not to sow the manure along with the seed, but to incorporate it with the soil before, as is done in the northern system.

A machine is now made which at the same time sows artificial manures in two rows and forms drills over them.

Time of Sowing.

The period for sowing the Swedish turnip in Scotland usually extends from the 1st May to the 1st June; for yellows, from the 20th May to the 20th June. In the south of England, and most parts of Ireland, the sowing may be almost a month later. But there, as in Scotland, turnips sown early have, as a rule, the best chance of becoming a full crop. Notwithstanding an occasional season in which mildew attacks the earlier-sown crops, it is an undoubted advantage, if the land can be properly prepared, to sow the seed as early as possible after the 1st of May.

In the south of England late turnips are frequently sown up till the end of August, and occasionally even in September. In these cases, however, heavy crops of solid roots are not looked for.

Quantity of Turnip Seed.

The quantity of seed required varies with the season and soil. The seeds of the Swedish variety are about one-fifth larger and heaver than those of the common turnip, and a correspondingly larger quantity must be used. Swedes sown in May require from 3 to 5 lb. of seed per acre. The latter quantity of good seed should be used in the earlier part of the season, if the soil is rough or of a stiff nature. If the season is somewhat advanced, and the soil finely moulded, from 2½ to 3 lb. may be sown. For yellows sown in May the quantity may be from 2 to 4 lb.; if sown in June, from 1½ to 2 lb. may be sufficient

Thick and Thin Sowing.—While thick seeding is expensive and injurious, in some seasons producing a rush of spindly plants, it is not prudent to sow too thinly. Not a few crops have been lost where a little more seed would have saved them. Moderately thick sowing sometimes helps to overcome an attack of the fly. As the season approaches midsummer, the weather gets warmer, the risk of fly diminishes, and a smaller quantity of seed is sufficient.

If the seeds could be evenly distributed, and if all could be depended upon to germinate and grow, 3 ounces of average yellow turnip seed, and 3½ ounces of swede seed per acre, would give a plant for every six inches of drill.

Selection of Turnip Seed.—Great care should be exercised in the selection and purchase of turnip seed. By un-

scrupulous sellers of seeds, turnip seed is sometimes mixed with old stock, or even with wild-mustard seed killed by immersion for one minute in boiling water. Home-grown seed, if fresh, is usually most reliable. Fine plump seed is better than that which is small and immature, and will produce a stronger plant and heavier turnip.

Depth for Turnip Seed.—The depth to which turnip seed should be put into the soil varies with the state of the weather and the condition of the soil. In dry weather, with the soil moderately dry, the seed should be put fully an inch under the surface. In wet weather, with plenty of moisture in the soil, from a quarter to a half inch will be sufficient.

MANURING TURNIPS.

The manuring of the turnip crop is a subject that demands, and will repay, careful attention from the farmer.

Dependence upon Manure.—It is quite essential for root crops of all kinds that a dressing of manure, usually very liberal, shall be given for their own special benefit. Turnips are gross feeders: they produce a great weight of material in a comparatively short space of time, and must therefore, if their success is assured, have within easy reach an abundant supply of readily available plant-food.

It is a characteristic of the turnip crops that they fail entirely upon impoverished soil. Upon a deteriorating unmanured soil grain will continue to produce some considerable yield long after turnips have failed upon it completely.

This peculiarity has been well shown at Rothamsted. There Norfolk white turnips grown for three successive years on two plots—one with no manure, the other with 12 tons of farmyard dung every year—gave in roots (omitting tops or leaves) the following results per acre :—

	No manure.		12 tons dung.	
	tons.	cwt.	tons.	cwt.
1st year .	4	3¾	9	9½
2nd „ .	2	4¼	10	15¼
3rd „ .	0	13¾	17	0¾
Average	2	7¼	12	8½

On another piece of land an unmanured plot was cropped continuously on the Norfolk four-course system,—roots, barley, clover (or beans or fallow), wheat,—and while the turnips coming at intervals of four years fell from 3 tons 5½ cwt. in the first year to 1 ton 6 cwt. in the second crop of roots, and to 5 cwt. in the tenth crop, the barley following after these miserable crops of roots, without any manure whatever, gave the respectable average of 31⅝ bushels per acre for the whole of the eleven crops grown in this way at intervals of four years.

It is thus evident that turnips readily exhaust the soil of the available supply of plant-food suitable for them, and that as foragers in poor soil they are not equal to the grain crops.

In quite an exceptional degree, therefore, turnips are dependent upon dressings of manure applied for their own special benefit. No farmer attempts to grow turnips without an allowance of manure, in that or the previous season, no matter how fertile naturally or how high in condition the land may be.

An Exhausting Crop.—Assuredly the turnip crop is an *exhausting* crop. The fact that, in prevailing farm practice, it generally leaves the land better than it found it, is due, not to the influence of the roots, but entirely to the tillage and cleaning the land received in preparation for the roots, and to the surplusage in the dressing of manure.

It was at one time supposed and contended that turnips enriched the land by their large extent of leaf-surface absorbing nitrogen from the atmosphere, and leaving it in the soil for the benefit of succeeding crops. Careful investigations have shown that this idea is not well founded, and that the root crop, if wholly removed from the land, is the most exhausting of all the ordinary farm crops grown in this country.

These considerations all tend to emphasise the importance of the question of "manuring for turnips." Information bearing on the subject will be found in various parts of this work,—in the articles on "The Fertility of Soil," vol. i. pp. 317-334, the "Highland and Agricultural Society's Experiments,"

vol. ii. pp. 37, 40, and in the large section on "Manures and Manuring," vol. i. p. 446.

Elements Absorbed by Roots. — First, let us see what are the elements and the quantities of these elements absorbed by an acre of turnips. Reverting to the table on p. 326, vol. i., giving the weight and average composition of ordinary crops in pounds per acre, we find that the figures relating to common turnips and swedes are as follows :—

	Turnips.			Swedes.		
	Roots, 17 tons.	Leaf.	Total crop.	Roots, 14 tons.	Leaf.	Total crop.
	lb.	lb.	lb.	lb.	lb.	lb.
Dry matter . .	3126	1531	4657	3349	706	4055
Total pure ash . .	218	146	364	163	75	238
Nitrogen . . .	63	49	112	74	28	102
Sulphur . . .	15.2	5.7	20.9	14.6	3.2	17.8
Potash . . .	108.6	40.2	148.8	63.3	16.4	79.7
Soda . .	17.0	7.5	24.5	22.8	9.2	32.0
Lime	25.5	48.5	74.0	19.7	22.7	42.4
Magnesia . . .	5.7	3.8	9.5	6.8	2.4	9.2
Phosphoric acid . .	22.4	10.7	33.1	16.9	4.8	21.7
Chlorine . . .	10.9	11.2	22.1	6.8	8.3	15.1
Silica	2.6	5.1	7.7	3.1	3.6	6.7

Elements to be Supplied in Manure. — Now the next and all-important question is, What proportion of these elements has to be supplied in manure? In ordinary farm practice the only essentials of manure are nitrogen, phosphoric acid, and potash. To most soils not by nature calcareous, lime has to be applied at intervals; but the functions of lime in the soil are well known to be so different from those of what are generally understood as manures, that we will not here embrace the question of liming, but will assume that the soil is sufficiently provided with it. Of the other elements mentioned in the above table the natural supplies will almost invariably be ample enough for the wants of the crop.

Subordinate Elements. — On some soils the application of magnesium, calcium, and sulphur has produced a considerable increase in the weight of the turnip crop. But the good effects seem limited to certain soils, and are probably due more to chemical and mechanical agency than to the supplying of direct food to the plant. Thus caustic and carbonate of lime act upon soils by disintegration, and by causing a more rapid decay of the organic matter, liberate nitrogen, which acts as a plant-food to all crops, and in the turnip give an increase of shaw equal to that obtained by a small application of sulphate of ammonia. The addition of sulphuric acid, especially in a free state, must act upon and change some of the soil constituents.

Uncertainties in the Manuring Question.—Confining attention, therefore, to those three important constituents of plant-food—nitrogen, phosphoric acid, and potash—we have to consider what quantities of each of these should be applied to the different kinds of turnips in different conditions as to soil and climate. This, unfortunately, is not a simple mathematical question. There are so many uncertainties as to the character and contents of the soil, and so many disturbing influences in climatic variations, that the farmer, however scientific, careful, and capable generally, must always be to some extent working by chance. Moreover, the farmer has to keep in view the important considerations of profit and loss as well as the perfection of the crop. He is not content to discover merely what quantities of nitrogen, phosphoric acid, and potash would be likely to ensure a full crop of turnips. His great object is to learn what quantities of these constituents should be applied in order to secure the greatest

possible return for the outlay involved. The prudent farmer, like all prudent business men, works for profit. He wants not merely a *big* crop but a *paying* one as well.

Now in practice it is found that to apply to the land the exact quantities of essential manurial elements which analysis shows that the particular crop removes, would not be efficient and economical manuring. The reason for this is twofold. In the first place, there are the stores of fertility already in the land, which may be sufficient to provide much of all, and all or the greater portion of some, of the elements. On the other hand, the whole of the plant-food in the manure applied may not, in an available form, come within the range of the roots of the crop for which it was intended.

For guidance in manuring, therefore, the farmer has to rely largely upon practical experience as well as upon scientific formulæ. For instance, the general system of cropping pursued on the farm has to be considered,—whether the manure to be applied to the root crop has to serve for future crops, for what other crops, and for how many years the manuring is intended to last. This, indeed, is a most important point in arranging the allowance of manure for turnips,—a point which has been fully discussed in the chapter on "Manures and Manuring." Another important consideration is the manner of utilising the crop of roots—whether they are to be in whole or in part consumed on the ground by sheep, or entirely removed.

Turnip-tops are now seldom removed from the land: they are either consumed on it, along with the roots, by sheep, or they are cut off and ploughed in when the roots are pulled. In considering the after fertility of the land, the elements absorbed by the tops would therefore not have to be taken into account. In manuring for the roots, however, the entire contents of the crop must be kept in view.

Nitrogen, Potash, and Phosphoric Acid for Turnips.—It is found, then, that crops of common turnips and swedes absorb about the following quantities of nitrogen, potash, and phosphoric acid per acre:—

	Common Turnips, 17 tons (of bulbs).		Swedes, 14 tons (of bulbs).	
	Bulbs and tops.	Per ton (of bulbs).	Bulbs and tops.	Per ton (of bulbs).
	lb.	lb.	lb.	lb.
Nitrogen . . .	112.0	6.88	102.0	7.28
Potash . . .	148.8	8.58	79.7	5.69
Phosphoric Acid . .	33.1	1.95	21.7	1.55

These yields per acre are above the average for England, and below what would be reckoned good crops in Scotland, Ireland, and the best turnip districts of the north of England. From these figures, however, it will be easy for any farmer by a simple mathematical question to form a useful *estimate* as to the quantities of these constituents of plant-food which his crops of turnips are likely to absorb. We use the word estimate advisedly, because it should be remembered that such figures as these, giving the average composition of turnips, cannot be held to represent the composition in all cases with precise accuracy. Yet by multiplying the number of tons he expects to grow by the quantities per ton shown above, the farmer will come sufficiently near the actual facts to afford him a useful guide as to the supplies of the important constituents of plant-food which should be available to his crops.

Chief Manure for Turnips.—To judge by these analyses of turnips, one would conclude that potash and nitrogen should bulk more largely than phosphoric acid in manures for turnips. In practice, however, it is found that such is not the case. The dominant element in all special manures for turnips is phosphoric acid. It must in some form or other be applied to all soils, and in many cases constitutes the sole application for the turnip crop.

Nitrogen for Turnips.

In farm practice it has not usually been found that any considerable direct application of nitrogen has been repaid by an increase in the turnip crop. Yet it has been proved that the presence in the soil of readily available nitrogen is essential for the healthy growth of the crop.

Atmospheric Nitrogen for Turnips.—With their broad leaf-surface, turnips have by some been credited with the ability to draw a considerable quantity of nitrogen from the atmosphere. As to this question, there has long been differences of opinion among scientists, and these differences have been accentuated by reports issued by Mr Thomas Jamieson, Aberdeen, regarding his researches. The views expressed by Mr Jamieson, referred to in vol. i. p. 332, are strongly controverted by other agricultural chemists, and on the whole, for the present at any rate, one does not feel disposed to advise farmers to rely entirely upon atmospheric nitrogen for turnips.

Nitrogen in the Soil.—Practical experience has tended to show that, in most soils in good average condition as to cultivation and fertility, the turnip will find as much nitrogen as it can profitably take up. Certainly wherever a reasonable quantity of short or well-rotted farmyard manure is applied, there will be little or no need for any further application of nitrogen. On the other hand, where no dung can be spared, and where it is known or suspected that the soil is deficient in available nitrogen, the application of a small quantity may be expected to produce an increase in the crop.

Rothamsted Trials.—In summarising the results of the Rothamsted experiments upon different manures for turnips, the late Sir Henry Gilbert gave the following conclusions in reference to *nitrogenous manures*:—

1. It is entirely fallacious to suppose that root crops gain a large amount of nitrogen from atmospheric sources by means of their extended leaf-surface. No crop is more dependent on nitrogen in an available condition within the soil; and if a good crop of turnips is grown by superphosphate of lime alone, it is a proof that the soil contained the necessary nitrogen. In fact, provided the season be favourable, the *condition* of the land, as far as nitrogen is concerned, may be more rapidly exhausted by the growth of turnips by superphosphate than by any other crop.

2. If nitrogenous manures are used in excess—that is, in such an amount as to force luxuriance, that the roots do not properly mature within the season—there will be, not only a restricted production of root, but an undue amount and proportion of leaf.

3. Excess of nitrogenous manure tended to lower the percentage of dry matter and increase the percentage of nitrogen in the roots.

English Practice.—Notwithstanding the importance which the Rothamsted experiments place upon nitrogen for the turnip crop, it is not the rule in English practice to apply nitrogenous manures directly to turnips. As to this point, Professor Wrightson remarks: "Ammonia-salts and nitrate of soda, although producing an increase of leaves, do not greatly increase the yield of bulbs. Their effect, when applied alone on exhausted soils, is trifling; but where there is an abundance of available mineral food, an increase is no doubt effected by their application. This increase is, however, not commensurate with the expense, and the wiser system is to employ superphosphates in root cultivation, and hold back the ammonia-salts and nitrate of soda for application on the cereals or grasses."

Experiments with Nitrogen at Carbeth.—Mr David Wilson, D.Sc., of Carbeth, Killearn, Stirlingshire, conducted various experiments on the manuring of turnips, and with regard to nitrogen arrived at the conclusion that while turnips are not, upon soils in average condition, nearly so dependent upon supplies of soluble nitrogenous manures as the cereals, it will pay in most soils, when growing them without dung, to use a little nitrate of soda, or sulphate of ammonia, say fully 1 cwt. per acre. Nitrogen, he believes, is most likely to be required for roots when the soil is deficient in organic matter, and where the climate is warm and dry.

In a review of a large number of ex-

periments on the use of nitrogenous manures for turnips, Principal R. P. Wright states that the most effective method of applying nitrate of soda to the turnip crop is to give half the allowance in the drills at time of sowing, and the remainder as a top-dressing after the thinning of the young plants. In these trials the best results were got from nitrogenous manures by giving one-half in the form of sulphate of ammonia in the drills at the time of sowing, and the other half in the form of nitrate of soda as a top-dressing later on.[1]

Potash for Turnips.

Although potash bulks largely in the analysis of the root crop, the application of potash in the form of manure would not in all cases be followed with advantage. In most soils there are great natural supplies of potash, and, as a rule, all the additional potash required will be provided in a moderate dressing of farmyard dung. But in certain soils, notably those of a light sandy and gravelly nature, and in cases in which little or no dung is applied, it is more than probable that the addition of a small quantity of potash to the dressing of manure would be profitable.

Many instances have been observed of quite a remarkable increase in the crop from a moderate allowance of potash. These of course have taken place where all the elements and conditions necessary for the production of a large crop of roots are present excepting available potash. In manuring, the farmer should never forget the significance of the law of minimum—that law whereby the produce is limited, not by the combined quantity of all the elements present in the soil, but by the producing power of the supply of the essential element present in the smallest proportion.

Thus when potash is deficient, the application of it is followed by a marked increase in the crop.

Potash is usually most deficient in light gravelly soils in poor condition. Still it is the exception rather than the rule for land to be in need of potash for turnips. The conclusion which the majority of experimenters and observing farmers have arrived at is, that unless there is good reason to suspect that the particular field is deficient in available potash, it need not be included in the manure, at all events when a moderate quantity of dung is used.

An Excess of Potash Injurious.—Indeed it has been found in several cases that an excess of potash has injuriously affected the yield of roots, as in the Highland and Agricultural Society's experiment referred to on p. 37 of vol. ii. At Carbeth, Stirlingshire, Dr Wilson had similar experience. Potash salts equal to 2 cwt. of kainit per acre were tried on 22 plots, alongside 22 similar plots without potash, but dressed also with dung like the other plots. The results were—

	Average of 22 plots, per acre.	
	tons.	cwt.
Dung alone . . .	21	9
Dung with 2 cwt. kainit .	20	13

Decrease due to the kainit, 16 cwt. per acre.

Tried at Carbeth without dung on four different soils, potash gave a profitable increase in roots in only one soil. In the other cases the supply of potash already in the soil was sufficient. As to excess of potash, Mr Wilson remarks that "the mineral acids combined in these salts seem to be set free, and to do mischief to the crop." Mr Wilson therefore advises the withholding of potash, unless it is believed from actual experiment or observation that there is a deficiency of it in the particular field.

On some fields where kainit had not benefited the turnip crop, increased produce has been obtained from small allowances of potash in the form of muriate or sulphate of potash.

Test the Soil.—Here again let us urge the farmer to watch closely and *test* every year the condition of his land as to its supplies of the leading constituents in plant-food (vol. i. p. 326).

Phosphates for Turnips.

In all manures specially adapted to turnips, the dominant ingredient should be phosphoric acid. Under all circumstances, in all soils and situations, with dung and without dung, it is the almost invariable practice to furnish turnips with a phosphatic dressing in some form or other.

[1] *Trans. High. and Agric. Soc.*, 1906.

Too much Reliance on Phosphates.—There is a tendency in some parts of the country to place too much reliance upon phosphatic manures alone for the turnip crop. This should be guarded against, for with imperfectly balanced manuring the results cannot be fully satisfactory. It is more than probable that in many cases where phosphatic manures alone are applied, the addition of a small allowance of nitrogenous and potassic manures would very substantially increase the produce of the crop.

This would not likely be the case in land which is naturally fertile and in good heart from liberal manuring with dung and other lasting manures in previous years. But in land in poor or medium condition, it would be advantageous to add small quantities of nitrogenous manures and potash to the phosphates.

Superphosphate Manuring Exhausts the Soil.—In the economical manuring of any particular farm crop, it is important to keep in view the after condition of the soil—that is, the effect which, under the dressing of manure now applied, the crop is likely to exercise upon the general fertility of the soil.

In the manuring of turnips this consideration demands more attention than many farmers have been in the habit of giving to it. For it is tolerably well authenticated that by the injudicious—the excessive or exclusive—use of superphosphates for turnips, the standard fertility of the soil has in many cases been appreciably lowered.

Recouping the Soil.—The exhaustion of the lime of the soil which thus takes place by the growth of turnips from exclusive or excessive dressings of superphosphates may be prevented, or rather recouped, by the consumption by sheep on the ground, not only of the root crop but also of some other food, such as cake or grain. This is extensively done in many parts of the country, and is especially commendable where dung cannot be spared for the root crop. Indeed it is the rule in many districts to consume on the land by sheep the whole or greater part of any section of the turnip crop which had not received farmyard dung and was grown solely by artificial manure.

Phosphates with Dung.—In four years' experiments at Carbeth, Stirlingshire, the only artificial manure sown along with dung which repaid its cost in an increased crop of roots was superphosphate, applied at the rate of from 3 to 5 cwt. per acre. From a large number of plots in different fields and in different years, dressed with from 10 to 13 tons of rich covered-court dung, the addition of 5 cwt. of superphosphate gave an average increase of 2 tons 10 cwt. per acre in bulbs. The dung given here was probably sufficient to supply all the phosphoric acid required by the roots. The increase from the addition of superphosphate is therefore attributed mainly to its assisting the plant with easily assimilated phosphoric acid before it could lay hold of the more slowly acting dung. Another advantage, often one of great importance, is that the quickly acting superphosphates force the plants more rapidly past the stage in which they are attacked by the fly.

Phosphates without Dung.—Dr Wilson also experimented with phosphates without dung, and with and without the aid of other artificial manures. On land at Carbeth which is evidently above average fertility, the average produce of roots without dung or phosphates was 7 tons 17 cwt. per acre. With 8 cwt. 25 per cent superphosphate, the average produce rose to 17 tons 19 cwt.—an increase of 10 tons per acre.

Cheapest Phosphate for Turnips.—An important question, as to which there is a good deal of difference of opinion, is that of the most economical form of phosphate for the turnip crop.

From 1840 to 1870, Peruvian guano and roughly crushed bones, with the occasional addition of dissolved bones and superphosphate, were the manures chiefly employed to supply the nitrogen and phosphates to the turnip crop. Since the Chincha Island deposit of guano became exhausted, the other deposits, being inferior in ammonia and high in price, are comparatively little used. Crushed bones, more finely ground than formerly, are still in much repute for turnip manure in all light soil districts; while on the heavier soils dissolved bones and, still more, superphosphate, have become the general manures.

Mineral Phosphates.—Notwithstanding some opinions to the contrary, carefully conducted experiments have shown that phosphates from mineral sources, such as rock guano, coprolites, Carolina phosphates, and the phosphate from basic slag, when finely ground, act on the turnip crop more quickly than the phosphate in finely crushed bones, while the mineral phosphates can usually be bought at a much less price per unit. So long as mineral phosphates are cheaper the farmer in favourable circumstances as to soil and climate may do well to use them, in part at least, in place of crushed bones—taking care that *the grinding is as fine as possible*, and avoiding all the phosphates of alumina, and the crystalline apatite, which latter should always be dissolved before application.

Discrimination in use of Mineral Phosphates.—To use undissolved mineral phosphate successfully as a turnip manure, the farmer must exercise not a little discrimination. Some mineral phosphates will give excellent results in one soil, while in another soil, not very different in appearance, the effects will be disappointing. An exception is phosphatic slag, which is almost invariably effective on light and medium soils.

The various forms of phosphate are fully described in the section on "Manures and Manuring," vol. i. p. 493.

Superphosphates.—Superphosphate of lime, the characteristics of which are fully discussed at p. 501, vol. i., is extensively used as the source of phosphoric acid for turnips. In great parts of England, where the soil and climate are dry, it is indeed almost the only form of phosphates now used for turnips along with dung. In many cases it has been found the most economical form of phosphatic manure for this crop, producing a heavier yield than the same value of crushed or dissolved bones.

At Carbeth, Dr Wilson compared superphosphates with equal money's worth of ground Charleston phosphate. He obtained in four years an average of 10 per cent more weight of bulbs from the superphosphate than from the ground mineral phosphate. Dr Wilson also contrasted the superphosphate with Thomas slag. The results again were in favour of the former, at the existing prices of the two articles. Dr Wilson likewise considered the phosphates in guano dearer than those in superphosphate; but in contrast with the same value of *steamed bone-flour*, the superphosphate failed at Carbeth to sustain its supremacy. Steamed bone-flour mixed with superphosphate produced 13 cwt. more per acre than an equal money value of superphosphate alone. Dr Wilson adds that, making allowance for the nitrogen contained in steamed bone-flour, more phosphoric acid is got for the same money in this form than in superphosphate.

Along with dung, Dr Wilson prefers superphosphate (mainly for its quick action) to all other forms of phosphates. Without dung, he would provide the phosphates in a mixture of steamed bone-flour and superphosphates.

The Aberdeenshire experiments, described on pp. 51 to 56, vol. ii., have a very direct bearing upon this point. Note in particular what is said (p. 54) as to the influence of phosphates rendered soluble by sulphuric acid upon the tendency to "finger-and-toe," and as to fineness of grinding or perfect disaggregation (pp. 53 and 55) being as effective as dissolving in sulphuric acid.

Climate and Soil to be Considered.—In deciding as to the form of manure used, the characteristics of the climate and soil must be carefully considered. As to this point, Mr John Milne, Mains of Laithers, Aberdeenshire, who is a practical chemist as well as an extensive experimenter and successful farmer, remarks:—

"In cold wet districts, or if the crop is late in being sown, the quantity of soluble phosphate should be increased, as its effect is to force the crop to early maturity. In these circumstances, if farmyard manure is applied, little or no nitrogenous manure should be used, as its tendency is to keep the crop growing longer, and thus retard its maturity. Undissolved mineral phosphates always act best in warm early seasons, and do not show quite so well as soluble phosphates in cold wet years.

"In manuring, the farmer should be guided by the quality of his soil, the period of sowing, and probable character of the weather. If his soil is rough or

stiff, the sowing late, or the climate cold or wet, a pretty large proportion of soluble, precipitated, or very finely ground phosphate is advisable. If the soil is soft, the season early, and the climate dry, the phosphate need not be so finely divided, and a larger proportion of nitrogen may be beneficially used."

Basic Slag for Turnips.—This important fertiliser (described in vol. i. p. 499) is used with excellent results as a source of phosphates for turnips. It is specially suitable for soils deficient in lime.

Farmyard Manure for Turnips.

Throughout the country generally farmyard dung is the standard manure for turnips. It is the rule—which, however, has a good many exceptions—to apply the whole or the greater portion of the farmyard dung to the potato, turnip, and mangel crops. The prevalence of the practice is a tolerably sure indication that a dressing of dung is well suited to the turnip crop.

Supplementing Dung.—But while a dressing of dung is highly beneficial to the turnip crop, it may be found advisable to supplement it with some more quickly acting fertilisers, such as superphosphate or slag, nitrate of soda, and potash. Much will, of course, depend upon the condition and quality as well as the quantity of the dung. Well-rotted dung acts more quickly than fresh dung, while if it has been enriched by the consumption of concentrated foods, it will be still more efficacious. It is highly important that the plants be pushed forward rapidly in their first few weeks, so that they may get beyond the ravages of insects. For this purpose a dressing of some quickly acting phosphatic manure will be a valuable supplement to the more substantial but slower farmyard dung. As we have seen, superphosphate or a mixture of very finely ground mineral phosphate and steamed bone-flour will likely be most suitable. When dung is applied to soils in good condition, only a small quantity of any readily acting phosphate is required, but when quick growth is wanted superphosphate will serve the purpose very well.

Is Dung Essential in Turnip Culture?—This question has been much discussed. It is still the subject of difference of opinion. Many noted agriculturists, including Professor Wrightson, contend that good crops of swedes cannot be grown without dung. Others hold that it is not by any means essential, and that better results will be obtained by applying the dung to other crops, such as potatoes, or on pasture or meadowland, and growing the turnips entirely or mainly with substantial artificial manure. It is going too far, we think, to hold that swedes cannot be grown advantageously without dung. As a matter of fact, good crops of swedes *are* grown without dung; and the feeling is gaining ground that some proportion of the excessive dressings of dung which are often applied to swedes might be more advantageously utilised for other purposes.

Assuredly it is most desirable that a substantial dressing of good farmyard dung should be available for swedes. It is the best foundation of all for a successful crop; and, as a rule, it will be found the safest practice to devote the main portion of the dung to the swedes. But while dung is probably necessary to ensure a maximum crop of swedes, it is not absolutely essential for the production of a profitable crop. In some cases it may be desirable to grow a greater breadth of swedes than the available supply of dung will cover; and this may be done by the use of artificial manures. Generally, however, it is deemed prudent to substitute yellow turnips when the dung becomes exhausted.

It would be unnecessarily restricting the operations of the educated and skilful farmer to tell him that he must not attempt to grow swedes without farmyard dung.

The softer varieties of turnips are grown very extensively, and with great success, without the slightest particle of dung,—great care, skill, and liberality being of course necessary in these cases in the use of artificial manure, so as to maintain the fertility of the land. Some farmers consider it imprudent to apply dung in drills for common turnips in light open soils, believing it to be better in this case to use artificial manures only, and to eat off the roots wholly or partially with sheep. This is a specially good plan for light land in outlying

parts of a farm. Unless the turnips are consumed on the land by sheep, it will most likely be necessary to top-dress some of the other crops which follow upon the land which received no dung for the roots. In particular, an autumn top-dressing to young grass would be advisable.

Quantities of Manures for Turnips.

The quantities of manure applied to the root crop vary greatly throughout the country. The ruling influences are the climate, the natural character of the soil, its condition as to accumulated fertility or exhaustion, the purposes for which the roots are intended, and the general system of farming pursued.

Yield and Quantity of Dung.—The consideration which most largely regulates the amount of manure—that is, where the objectionable practice of applying all the manure for the rotation with the root crop has been abandoned—is the suitability of the district and the field for the production of a heavy or light crop of roots. Where a crop of 25 to 30 tons per acre is to be looked for, the allowance of manure must, as a matter of course, be much larger than where the yield is not likely to exceed 12 to 15 tons. These figures roughly represent the respective yields of the best turnip-growing districts of Scotland, Ireland, and the north of England, and in the midland and southern counties of England, and thus in the latter the prevailing quantities of manure applied are much less than in the Green Isle and north of the Humber.

The general questions to be considered in deciding as to the quantities of manure for the various crops have already been fully discussed in the chapter on "Manures and Manuring," vol. i. pp. 446-520. See in particular pp. 486-520. Here, therefore, a very few notes as to the prevailing customs will suffice.

Scottish Dressings.—In Scotland, in the north of England, and in Ireland, the allowances of dung vary from 5 to 20 tons per acre, and the accompanying dressings of manure from 3 to 8 or 10 cwt. of phosphatic manures, ½ to 3 cwt. of nitrogenous manures, and ½ to 3 cwt. of potash salts. More general quantities of dung run from 8 to 15 tons. Along with from 10 to 12 tons of dung, from 3 to 5 cwt. of phosphatic manures, 1 cwt. of nitrate of soda or sulphate of ammonia, and 1 to 1½ cwt. of kainit, would be a liberal dressing. For swedes some farmers give as much as 12 to 14 tons of good dung, 4 cwt. of mineral superphosphate, or an equivalent of basic slag, 2 to 3 cwt. crushed or dissolved bones, 1 cwt. of nitrate of soda, and 1 cwt. of kainit. Others curtail the artificial manure to about 3 or 4 cwt. superphosphate, or an equivalent of basic slag, ½ cwt. of nitrate of soda, and ½ cwt. of kainit. Often the two latter are omitted altogether; still more often the potassic manure is omitted, and the small allowance of nitrogenous manure included.

Advantage of Heavy Dressings Questionable.—Several of these dressings of artificial manures along with dung are assuredly very heavy. Many careful and successful farmers are doubtful as to the economy of such liberal and costly additions to the supplies of dung. By his carefully conducted experiments at Carbeth, Stirlingshire, Dr Wilson was led to the conclusion that the usual practice in many turnip-growing districts of expending from 30s. to £2 per acre upon artificial manure, to apply along with dung, is not a profitable one, and that in many of these cases half the rent of the land might be saved by reducing this outlay.

Certainly the once practised method of applying manure—dung, bones, and guano—to the turnip crop to serve for the entire rotation, has been exploded as thoroughly unsound. The allowance of dung for the rotation may of course be, and is still, applied to the roots, and with good effect; but with the artificial manure the case is entirely different. In regard to these, it is a safe rule to apply no more at any one time than you expect the first crop will profitably utilise or repay. A reasonable exception to this rule would be a dressing of crushed bones, particularly for grass land.

Moderate Dressings of Dung.—When the supply of dung is not sufficient to go over the entire root break, it is a good plan to lessen the allowance per acre, and make the dung go as far

as possible, increasing the quantity of artificial manure in proportion. Better far give 8 tons to the entire break than 12 tons to a certain portion, and none to the remainder—better especially for the after fertility of the land.

Artificial Manures alone.—When no dung can be spared, the allowance of artificial manures has to be very liberal. In some cases the allowance is as high as from 5 to 6 cwt. superphosphate, 2 to 3 cwt. steamed bone-flour or crushed or dissolved bones, 1 to 2 cwt. of nitrate of soda, and 2 to 3 cwt. of kainit, or an equivalent of muriate or sulphate of potash. In other cases, again, from one-half to two-thirds of these quantities are supplied, the potash often being omitted altogether. In many cases superphosphate at the rate of 8 to 10 cwt., and 1 to 2 cwt. of nitrate of soda, constitute the sole dressing. Others use a portion of finely ground mineral phosphate, and basic slag is now largely used as the phosphatic manure.

But the variations in the individual dressings are so numerous that it would be impossible to fairly represent them here.

Southern Dressings.—The most general dressing in England, where a crop of from 12 to 18 tons is expected, is from 8 to 12 tons of dung and 3 cwt. of superphosphate per acre. A small allowance of guano or nitrate of soda, from ½ to ¾ cwt per acre, is often drilled along with the superphosphate and the turnip seed, but this plan is regarded by many leading authorities as unprofitable.

Necessity for Individual Judgment.—In arranging the quantities of manure for turnips, as in most other farm operations, the circumstances of each individual case must be carefully considered. General rules are subject to many variations, which each farmer must decide upon for himself. A careful study (aided by a few experiments, which should always be going on) of the condition of the soil and its capabilities under favourable circumstances as to fertility will be the safest guide as to the most profitable quantities of manure to apply. It is a point in farm management which demands the very best attention from the farmer.

Application of Manure for Turnips.

The general methods of applying manures, and the principles upon which these should be regulated, have already been dealt with (vol. i. pp. 511-520). What is said there should be carefully studied in connection with the culture of turnips.

Dung.—As to the merits and demerits of the various practices of applying dung in the autumn, and on the flat surface, and in the drills in spring, enough has been said in the pages just referred to.

Upon heavy lands where the dung is available in time, the best and most general practice is to plough down the dung with a shallow furrow in the autumn or early in winter.

Where this has not been done, and where the turnips are to be sown on the flat surface, the dung is spread on the flat surface and ploughed down with a moderate furrow early in spring. Late dunging in this case is not to be commended, as the rank dung would be liable to unduly encourage the escape of moisture by keeping the surface-soil open.

The general practice where the turnips are grown in raised drills, is to spread the dung in the bottom of the drills at the time of sowing the seed; yet, as just explained, if the land is stiff and the dung available, autumn dunging, even with sowing in raised drills, is in many cases a beneficial method. It lessens work at sowing-time, and the dung helps to disintegrate the adhesive soil.

Carting Dung into Drills.—The old-fashioned method of emptying the dung from the carts in small heaps in every third drill is still in vogue in some parts. As a rule, however, it has long since given place to the much more expeditious and economical plan of throwing the dung in graipfuls from the cart into the drill as the horse moves along. A careful workman distributes the dung in this manner with admirable precision as to quantity, and it is left so as to make the work of the spreaders comparatively easy. The spreading of the dung is rendered still easier if the carter throws the graipfuls into the side drill (next to the drills already dunged), so that the wheel of the next cart may not go over the graipfuls,

which would be the case if the dung were, as is often the case, thrown into the drill in the centre of the cart. With short well-made dung thrown out in this way we have often seen two smart women spread as fast as one team with a drill-plough could open and close in.

Cart for Steep Land. — Ordinary farm carts are employed in carting out dung. In vol. i. p. 455, information

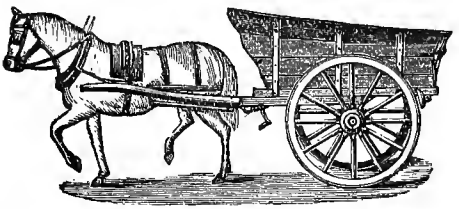


Fig. 606.—*Farm tip-cart.*

which should be consulted at this stage is given as to the position of dunghills and carting out dung. In steep land, when a load has to be conveyed down-hill, a cart similar to that shown in fig. 606, made by the Bristol Waggon Works Company, will be found useful. It is a

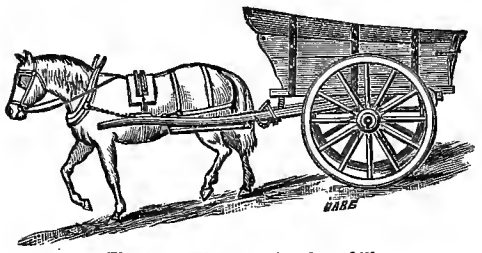


Fig. 607.—*Tip-cart going down-hill.*

tip-cart, with screw arrangement, whereby the load may, as shown in fig. 607, be raised off the horse's back.

Dung-spreading Apparatus.—Appliances have been invented for spreading the dung as it is thrown from the cart. A very useful apparatus of this kind is that shown in fig. 344, vol. i. p. 513, by which well-made dung is spread in drills even better than is possible by hand. This machine is attached to the rear of the cart, and is fed with the dung by the carter. It scatters the dung by its revolving prongs. Still, in most cases, dung is spread by the hand-fork or graip.

Sowing Artificial Manure. — The artificial manures are often sown either by hand or by drill or broadcast machines just before the drills are closed in. Manure-sowing machines are shown in figs. 345 and 346, vol. i. p. 520. It is a good plan to run a light harrow along the drills after the dung is spread, and before the artificial manure is sown. In some cases, instead of harrows, a long heavy pole is drawn over the drills. This helps to keep the quickly acting artificial manure nearer the rootlets of the young plants, and likewise still further pulverises the seed-bed. When there are many clods, some roll the drills before sowing the artificial manure. The manure is sown along the drill rather than broadcast, and may be done so quickly by a two-hand sower that one man will keep two drill-ploughs going, and supply himself with manure from the bags or carts deposited at the ends of the drills.

Southern Customs.—In England, wherever the turnips are sown in rows on the flat surface, the artificial manure is generally drilled in along with the seed with the dry or water drill, as already explained. A better method is the use of a machine, which at one operation sows the manure in two rows on the flat and raises drills over the rows, thus avoiding the bringing of the seed into direct contact with the manure. In many cases in England all the artificial manures are sown broadcast just before the seed is sown, although with a light application sown in this way the crops grown in rows on the flat are often disappointing. Broadcasting artificial manures is more satisfactory with raised drills, as in this case the scattered particles of the manure are gathered towards the plants by the operation of the drill-plough.

For the flat-row system the best plan perhaps is, where the artificial dressing consists entirely of superphosphate, to drill the whole of it along with the seed, and where other manures as well as superphosphates are given, to drill the greater portion of the superphosphate along with the seed, and sow the remainder with the other manures broad-

cast, and harrow in, following with the roller.

Kainit is in many cases found to give the best results when sown in the preceding autumn.

Top-dressing Turnips.—The practice of top-dressing turnips is rarely pursued. If nitrogenous manure is required, some consider it a good plan, especially in wet climates, to hold it back till the plants are about ready for singling, and then apply it in the form of a top-dressing of nitrate of soda.

Experiments in the North of Scotland.

Aberdeen and North of Scotland College of Agriculture has carried out a considerable number of experiments on the manuring of the turnip crop. As has been found in most other Scottish experiments on this crop, under ordinary conditions of practice available, phosphate is by far the most important artificial manure for the turnip crop. Under average conditions, and especially where dung is used, nitrogenous manures have comparatively little effect, while potassic manures come intermediate. On the average they produce a greater increase of crop than nitrogenous manures, but their effect depends much upon the nature of the soil, and is very variable.

Fine Grinding in Manures.—A series of experiments upon the effect of fine grinding in the case of bones and other insoluble phosphatic manures showed similar results to those obtained in the experiments of the Highland and Agricultural Society on the same subject—namely, that in order to obtain a rapid and remunerative return for bones used as manure for the turnip crop, the bones must be finely ground, and that the more finely they are ground the better is the return they give. In particular, the experiments brought out that steamed bone-flour when used so as to give an equal weight of phosphate gave a better return than even the finest commercial bone-meal. Steamed bone-flour is more finely ground than even the finest bone-meals, and its superior action could only have been due to its superior fineness of grinding. Otherwise it was at a disadvantage compared with bone-meal, as it contains both less organic matter and less nitrogen. The dressings of bone-flour had the further advantage of costing less than the bone-meal.

Basic Slag *versus* Superphosphate.—In two series of experiments the composition and feeding value of turnips manured with basic slag were compared with those of similar turnips manured with superphosphate. The feeding value was determined by feeding experiments with cattle. Very little difference in quality was found between the two different lots of turnips. Certainly the slag-manured turnips were not found to be of any poorer quality than those which received superphosphate.

Experiments in the North of England.

Experiments conducted by the Durham College of Science, Newcastle-on-Tyne, have given better returns from dung when applied for roots in spring than when applied in autumn or winter. They have also shown that large dressings of dung are not so profitable for roots as moderate dressings of about 10 to 12 tons per acre.

A striking result in these trials has been that dung alone has frequently given nearly as good results in the crop of swedes as dung and accompanied by artificial manure, though it has been noticed that when the effects upon the other crops in the rotation are taken into account the combination is distinctly profitable. A good average dressing for swedes and common turnips was found to be from 10 to 12 tons of farmyard dung, 4 cwt. basic slag, 1½ cwt. superphosphate, and ¾ cwt. sulphate of ammonia per acre.

When artificial manure was used alone the following dressing did well for turnips of all kinds: 4 cwt. basic slag, 1½ cwt. superphosphate, ¾ cwt. nitrate of soda, 1 cwt. sulphate of ammonia, and 1 cwt. of muriate of potash. All these manures were usually applied in the drill just before the seed was sown. In some cases it is thought well to apply the nitrate of soda as a top-dressing in moist weather two or three weeks after hoeing.

Experiments in the South of England.

At different centres in the southern counties of England trials have been

made in the manuring of the turnip crop. An exhaustive series of experiments, conducted on about thirty farms by the University College, Reading, brought out suggestive results.

It was found that the omission of phosphatic manures made it impossible to obtain remunerative crops of swedes. A small allowance of nitrogen was always beneficial, and so was potash, at about half the centres. A general conclusion was that moderate dressings were the most profitable.

Manures Preventing Blanks. — A striking result in these trials was the influence which the manures had upon the regularity of the plants. Where the land was unmanured, or only received small dressings, many gaps were met with in the rows. On the other hand, where the dressing of manures was fairly complete very few plants failed, the crops being remarkably even in growth. The presence of readily available manure close to the germinating seed greatly assists the seedlings in their early growth, and helps to overcome the attacks of fungi and insects as well as the influence of drought.

Welsh Trials.

A large number of experiments in the manuring of swedes have been conducted by the Agricultural Department of the North Wales University College at Bangor. The objects were to ascertain—

(*a*) The comparative returns from moderate and large dressings of farmyard manure.

(*b*) The extent to which it is profitable to supplement farmyard manure with artificial manures.

(*c*) The best forms and quantities of artificial manures for use: (1) alone, (2) along with farmyard manure.

The results of the trials showed that, in average circumstances, in North Wales a fair dressing of farmyard manure, say, 10 or 12 tons an acre, will give a profitable return. As a rule, if more than this be given, the extra manure will not pay for use. With such a dressing (10 or 12 tons an acre) artificial manures will only pay if used in small quantities, not more than 3 or 4 cwt. an acre, most or all of which should be superphosphate, or, in special cases, basic slag. This combination, if climatic and other conditions are favourable, can be relied on to produce a full crop, and in several cases crops of over 40 tons an acre have been grown with it.

Artificial Manure alone.—The most profitable crops have, as a rule, been those grown with artificial manures alone, and not only have they been the most profitable, but, on the whole, have been little inferior in actual yield per acre to those grown with farmyard manure, either alone or along with artificials.

In this connection it is necessary to point out that—particularly in Anglesey and Carnarvonshire, where the majority of the root experiments have been carried out—the rotation usually followed includes grass left down for five or six years, so that, apart from any dressing of farmyard manure, there is always a fair amount of organic matter left in the soil for the succeeding root crop.

The most profitable mixture of artificial manures for use without farmyard manure has generally been a moderate quantity (4 or 5 cwt.) of superphosphate, together with 2 or 3 cwt. of kainit per acre.

Nitrogenous manures, as a rule, have barely paid for use even when no farmyard manure has been given.

In some cases, chiefly on the heavier soils, basic slag has given better results than superphosphate, and in most cases it has been only slightly, if at all, inferior to an application of superphosphate of equal money value, even when applied in the drills in late spring.

Dissolved bones, fish-meal, basic superphosphate, and bone-meal, have in most cases given fairly good returns, but not sufficiently so to justify the use of these manures in preference to superphosphate or basic slag at current market prices.

Similar trials in the manuring of swedes were conducted by the Agricultural Department of the University College of Wales at Aberystwyth, and, on the whole, similar results were obtained. In this case the manuring was suited to soil of medium fertility on the Silurian formation. Here 15 tons of dung without any artificial manure did better than 10 tons, the 5 additional tons of dung raising the yield by about

2 tons per acre. With a small dressing of artificial manures (3 to 6 cwt. of superphosphate, ½ to ¾ cwt. sulphate of ammonia, and about 1½ cwt. potash), 10 tons of dung per acre gave a profitable return in swedes. Basic slag did almost as well as superphosphate. An application of potash manure seemed necessary when no dung was applied. Without dung the best yield was got from 6¼ cwt. superphosphate, 3 cwt. kainit, and ⅞ cwt. of sulphate of ammonia per acre.

SINGLING AND HOEING TURNIPS.

The turnip crop requires prompt attention at the time of the singling of the plants and the hoeing of the drills.

Influence of Weather.—The seed-leaves usually appear in from three to seven days after sowing. The plants grow rapidly in fine dry weather, if the nights are free from frost. Until the plants are of considerable size, heat and dryness favour their growth, while at this stage much rain is not favourable.

Turnips should be singled when the leaves measure about an inch across.

Drill-harrowing or Horse-hoeing.—But before singling or hand-hoeing is commenced, operations may be performed which will make the labour of hoeing more easily performed, and by further loosening the soil tend to promote the growth of the plants. If the weather is dry, the drills should be run between by a drill-cultivator or scuffler, let in as deeply as possible. But the width stirred should not exceed twelve inches, for if set wider the land will be too much drawn away from the plants before the process of singling is finished, and the raised drill too much reduced.

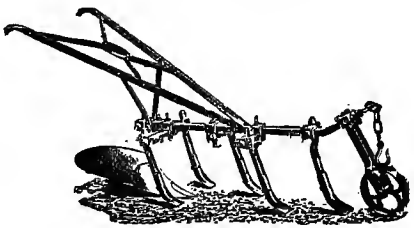


Fig. 608.—*Drill cultivator.*

Fig. 608 represents a type of a drill-cultivator made by T. Hunter, Maybole, and fig. 609 Martin's drill horse-hoe,

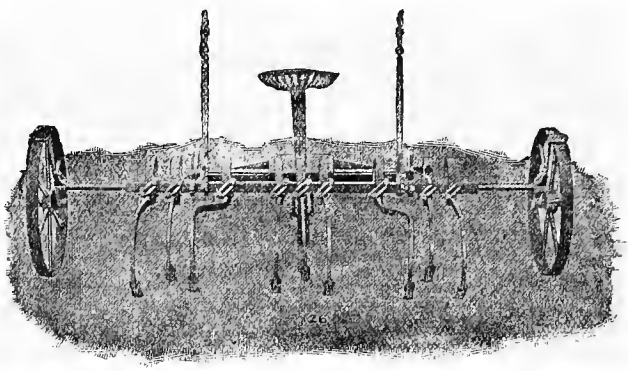


Fig. 609.—*Drill horse-hoe.*

which can be adjusted to work either in drills or in rows on the flat.

Harrowing across Flat Rows.—In the south a sort of drag-harrow, in some cases similar to a light Scottish drill-harrow, is drawn right across the flat rows before the first horse or hand hoeing, the object being to loosen the surface-soil, pull out surface weeds, and thin out the plants a little. Careful turnip-growers in the north do not approve of disturbing the plants thus early and in such an irregular fashion.

Drill-Scarifier.—A drill-scarifier such as that made by T. Hunter, Maybole, shown in fig. 610, is used largely and successfully for paring away the sides of the drills, thus destroying weeds, and

bringing the drills into the intended form, leaving less work for the hand-hoe.

Thinning-machines.—The singling of turnips by machine has been found to be a very difficult task, and complete success has not yet been attained. Still,

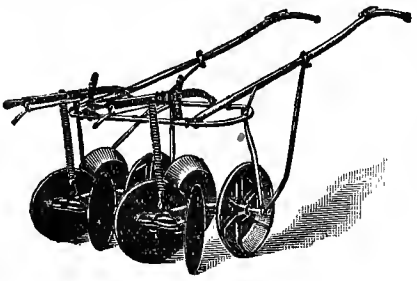


Fig. 610.—*Disc drill scarifier.*

machines have been brought out which save a certain amount of labour by partially thinning the plants, rendering easier the perfect thinning by hand.

Hand-hoes.—The hand-hoe used in thinning turnips is a simple instrument. Yet even in it improvements have been introduced in recent times. Instead of the shaft or handle being closely attached to the blade, it is now often made with a bow-shaped attachment, as shown in fig. 611. A hoe of this pattern works more lightly and cleanly than the hoe of the old shape, shown in fig. 612. The length of the blade of the hoe varies

Fig. 611.—*Improved hand-hoe.*

Fig. 612.—*Turnip hand-hoe.*

a Thin iron plate. *b* Eye of plate. *c* Wood shaft.

from 5 to 8 inches, according to the width usually left between the plants. Excellent hoes can be made cheaply from disused scythe blades.

Process of Hand-hoeing on Raised Drills.—As already mentioned, the turnips should be thinned when they measure about an inch across, when the tops are well into the rough or second leaf. The hoer ought to be taught to draw the hoe towards himself or herself in pulling out the spare plants, and to work as lightly as possible. If the plants are pushed away from the hoer, a deeper hold of the soil must be taken, a greater quantity of soil will be removed from the remaining turnips, the drills will be more pitted and levelled, and the plants thus too much denuded of support. Hoers generally take pride in their work, striving to leave the drills as high and symmetrical and as smooth in the surface as possible, with all weeds thoroughly removed—uprooted, not cut—and the plants thinned to precise distances as arranged, care being taken to leave strong well-formed plants, and never two together.

Hoeing-matches.—In some parts of the country hoeing-matches in the evening are quite an institution, and there is often great enthusiasm amongst the rival hoers—the farmers' families and servants of the surrounding district. These friendly contests are very properly encouraged by farmers, for they stimulate tasteful and careful hoeing, which in turn has a considerable influence upon the yield of the crop—far greater than would at first thought be imagined.

Good and Bad Hoeing.—It is quite within reason to say that the difference in the yield between a carefully hoed piece of ground—hoed as we have indicated above—and another hoed carelessly, with irregular intervals between the plants, weak plants left instead of strong, two plants sometimes left together, and the drills cut deeply into, and weeds only partially removed,—in short, between good and bad hoeing,—may very easily amount to from 2 to 4 tons per acre!

Hand-hoeing in Flat Rows.—Here, also, the plants should be drawn towards the hoer. Indeed, as will be readily understood, the great part of the hand-hoeing on the flat must be done in this way, as it is more difficult to push out weeds in the flat row than on the raised drills.

Speed of Hoers.—The amount of work done by hoers varies according to the soil, the width of the drills or rows, the intervals left between the plants, the thickness of the seeding, and the stage

at which the hoeing is done. If the soil is clean in raised drills, the plants not too thick, and taken at the proper size, an average hoer should overtake an imperial acre in from twenty-five to twenty-seven hours. If circumstances are very favourable, it may be done even in twenty hours; and if very unfavourable, it may take forty to forty-five hours to single an acre. If the drills are well scarified, the work is much lighter.

Expert men-hoers often go over the ground almost as quickly in the flat-row system of the south, where the rows may be only from 18 to 20 inches apart. But it would be all the better for the crop if a little more pains were taken with the hand-hoeing than is often the case.

In Scotland, Ireland, and the north of England, women do a large portion of the hoeing; but in the midland and southern counties of England it is performed almost entirely by men and lads.

Thinning by Hand.—In some cases when a greater breadth of plants comes forward at one time than can be gone over with the hand-hoe as quickly as may be considered desirable for the sake of the crop, thinning by hand is resorted to. This is an expeditious method of averting injury by the overcrowding of the young plants. In the long-run, however, it increases the cost of thinning and hoeing.

The better system of management, therefore, is to have a sufficient force of hoers to overtake the thinning as the plants become ready for the process. In average seasons the sowing is done so that the plants come forward to the hoe in breaks; but irregularities in the weather may upset this arrangement, and result in a pressure of work at certain times in the hoeing season, perhaps justifying recourse to hand-thinning if an extra force of hoers cannot be obtained. In any case, some farmers, who are particularly careful of their turnip crop, would give the preference to the hand-thinning, because by it a little more care can be exercised in leaving the strongest plants. At the same time weeds are usually more thoroughly dealt with by the hoe.

In some parts the thinning is done partly by the hoe and partly by hand. The hoers go on before, taking gaps out of the row of plants, leaving little bunches of perhaps three to half a dozen plants, while lads and women follow, and single these bunches by the hand, taking care to leave in the strongest and most promising-like plant in each bunch.

Transplanting Turnip Plants.—Common turnip plants cannot be transplanted with success. With swedes, however, transplanting is often done, to fill up blanks in the drills. The results are fairly satisfactory, sometimes yielding nearly half the weight of an average bulb.

Distance between Plants.

There has been much discussion, and there is still wide difference of opinion, as to the distances which should be left between turnip plants. The prevailing practice in this matter has undergone many modifications and alterations since the introduction of turnips as a regular field crop throughout the country generally.

Results from Short Intervals.—The late Mr Stephen Wilson, North Kinmundy, Aberdeenshire, conducted exhaustive trials with turnips thinned to different widths on seven separate farms, and in reference to the results he stated that such uniformity was shown as hardly left any doubt that in general 6-inch intervals will ensure a heavier crop of swedes or of common turnips than either 8- or 9-inch intervals. Indeed he satisfied himself, after all his trials with many sorts of turnips, in favourable and unfavourable seasons, under ordinary rotation of cropping, that 6-inch intervals will give a heavier crop than any wider interval.

Prevailing Intervals.—These experiments by Mr Wilson, and other more limited trials, no doubt tended to shorten the intervals left between turnip plants in certain districts. The prevailing intervals are still, however, considerably wider than Mr Wilson advised. Where the system of raised drills obtains, the intervals most general are from 9 to 10 inches in the cases of swedes, and from 7 to 9 inches for common turnips. A good deal depends upon the known habit of the particular variety of roots, whether it is

inclined to develop large or medium bulbs. The soil and climate must also be considered, for under conditions which favour the growth of large roots the intervals should be longer than where small roots are expected.

The space between the plants should of course vary with the width of the drill, or between the rows of plants if the crop is grown on the flat surface. The most general width of the raised drill is 27 inches, and, as will be readily understood, the plants may be left nearer each other in these wide drills than in the much narrower flat rows which abound in the midland and southern counties of England. These flat rows are usually only from 16 to 20 inches apart, and so the intervals between the plants there most frequently vary from 13 up to 16 inches for swedes, and about 2 or 3 inches less in the case of other varieties of turnips.

Growing Roots in Squares.—There is little doubt that the maximum weight per acre of roots would be obtained by growing them at equal distances apart in all directions, in squares of one foot or 14 inches for instance. Indeed it was found by experiments in Canada that a better crop resulted from placing the plants in the centre of a square unit than in the middle of an oblong unit, as in the case of common drilling.

Advantages of Drills.—But there is a practical advantage in the drill and row systems which far outweighs any loss in the produce of roots. The cleaning and tilling of the land are facilitated, and thus by growing them in tolerably wide rows or drills the root crops take the place of the costly "fallows" of olden times.

Medium and Large Roots.—One important point which should be kept in view in discussing and deciding as to the best intervals to be left between turnips is the ascertained fact that, as a rule, medium-sized bulbs show a higher specific gravity and contain a greater percentage of useful feeding material than exceptionally large-sized roots. This is the case in a marked way with the common varieties of turnips; it is slightly less marked with most kinds of swedes. "Large" and "small" are comparative terms. It is claimed for some of the improved varieties of swedes that large bulbs are more nutritious than small ones. What is meant in this case of course is, not roots of abnormal dimensions, but what the practical farmer would regard as large roots grown under normal conditions.

The object of every farmer should certainly be to grow a big—that is, a heavy—root in relation to the space allotted to it. What has been taught by investigations as to the nutritive properties of roots of different sizes is not that small varieties of roots should be cultivated, but that the maximum quantity of good feeding material per acre is more likely to be obtained by growing (at shorter intervals) a greater number of medium-sized roots than a smaller number (at longer intervals) of abnormally large roots—this, too, even although in both cases the gross weight of the produce may be equal. In other words, three medium roots—"big-little" roots—weighing each 3 lb., and grown in, say, 30 inches of an ordinary drill, will, as a rule, contain less water and more solid nutritive matter than two bulbs of 4½ lb. each, grown in the same area of ground.

Moderate Intervals.—The teaching of modern investigation is therefore decidedly in favour of shortening the intervals between the turnip plants. For common turnips from 7 to 9 inches should perhaps be the range in drills from 26 to 28 inches wide, and for swedes 1 or 2 inches more. In flat rows from 16 to 20 inches wide, suitable intervals would be from 9 to 11 inches for common turnips, and from 11 to 13 inches for swedes. In dry seasons favourable to mildew the wider intervals will likely give the best results. The free exposure of the plants to the atmosphere, as in wide singling, has a tendency to check the development of mildew.

Irregularity in Growth of Turnips.—Notwithstanding every care taken to single the plants at equal distances, it will usually be found after the crop has made some progress in growth that irregularities appear both in the distances apart and in the size of plants. Unless the seeding is very liberal, plants are apt to appear and grow somewhat irregularly, especially in dry weather. A good hoer will strive to leave a strong plant, even if an extra inch or two beyond the

distance intended. After hoeing, plants are occasionally pulled up by crows and wood-pigeons, and cut across by wire-worm and grub-worm. Some of the plants receive other injuries which prevent growth. The smaller and more backward get shaded and overtopped. The available supply of manure is appropriated by their more vigorous neighbours. Manure, especially dung, is not always so evenly spread as it ought to be, and it often happens that an average field will show not a little irregularity both in size of bulbs and distance apart. Indeed it is only on the most fertile and easily pulverised soils, and under the most favourable circumstances of soil and climate, that the bulbs approach equality of size and regularity of distance apart.

After Cultivation.

The cultivation required by turnips after the singling has been completed consists of hand-hoeing once or twice, and horse-hoeing between the rows of plants two, three, or more times. The season and condition of the land as to weeds and tilth will regulate the number of hoeings.

About ten or fourteen days after singling, the horse-hoe or drill-harrow is run along the drills or between the rows of plants, to stir up the soil and eradicate weeds. The second hand-hoeing may follow in a few days, the hoers removing all weeds left by the horse-hoe or drill-harrow, and loosening, but not displacing, the earth around the plants. If in any case two plants have been left together, in singling one should now be carefully pulled by hand.

Care in Hoeing Strong Plants.—It is no doubt beneficial to stir the soil around the plants even after they have grown almost to cover the drill with their tops. In this operation, however, the greatest care must be exercised not to cut the rootlets, which are now spreading like net-work in all directions, and which cannot be cut or seriously disturbed without less or more injury to the crop. For this reason the third hand-hoeing is often abandoned.

Earthing-up Turnips.—It is sometimes found beneficial, chiefly on wet soils, to earth-up turnips immediately after the second hand-hoeing. The main advantage of this is, that surplus surface-water is carried away more freely. In dry soils, however, the earthing-up may do more harm than good. Some of the rootlets may be cut or injured by the plough, and their development thus impaired. Then the sharp, deep furrows are troublesome, even dangerous, in case of sheep feeding on the roots, as sheep may get upon their backs in the ruts, and perish if not released in time.

If earthing-up is to be done at all, it should be carried out as soon as possible after the second hoeing. The younger the plants the less will be the injury or disturbance to the rootlets. But the earthing-up of turnips is neither a general, nor, as a rule, a commendable practice, except for the protecting of the roots from frost, and then it is done after growth has ceased.

Turnip Pests.

The pests of various kinds which prey upon the turnip crop are dealt with separately in this volume.

STORING TURNIPS.

The turnip crop is not only an expensive one to grow, but the amount of attention it requires in its different stages to secure a satisfactory yield is very great. It is therefore desirable that when it has been grown every effort should be made to turn the produce to the best possible account. The first step towards this end is the timely storing of the roots.

Advantages of Storing Roots.—The advantages which arise from the storing of roots are manifold. Chief amongst these are, the preservation of the crop from the effect of the frosts and thaws of winter, the procuring of a regular supply of fresh and clean food for the animals upon the farm, the prevention of the growth of the tops in spring, and keeping the land free from carting and consequent poaching in unsuitable weather. Roots, like fruit, ought to be stored before they become over-ripe; the months of October and November are therefore the most suitable for the work. The other operations of the farm allow time for it at this

season; and the crop is generally in a fit state of maturity, as well as the land being dry.

Keeping Properties of Turnips.—Yellow turnip will continue fresh in the store until late in spring, but the swede has a superiority in this respect over all others. A remarkable instance of the swede keeping in the store, in a fresh state, was observed in Berwickshire, where a field of 25 acres was pulled, rooted, and topped, and stored in the manner shown in fig. 613, in fine dry weather in November. The store was opened in February, and the cattle continued on the roots until the middle of June, when they were sold fat, the turnips being then only a little sprouted, and somewhat shrivelled, but sweet to the taste.

Time for Storing Swedes.—It has been contended by some that the best time for storing swedes is before vegetation makes its appearance, in March or April, when they are heaviest. By experiments made in England, it was found in weighing swedes on the 16th of November, and again on the 16th of February, from the same field, that the crop had increased in weight in that time no less than 2½ tons per acre. This experiment corroborates the belief largely held that swedes gain weight until vegetation recommences in April. If there were no danger of damage by frost, it would therefore be prudent to

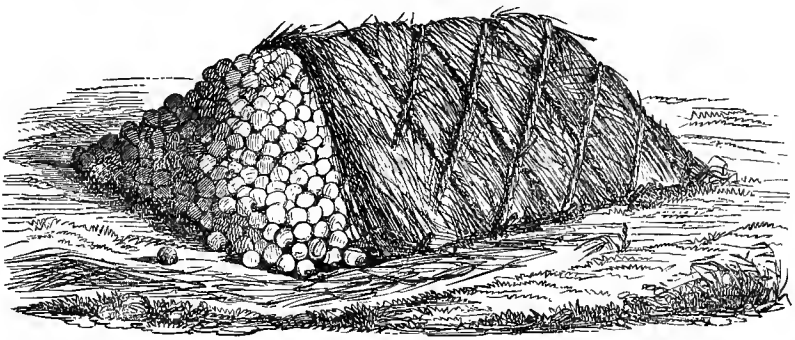


Fig. 613.—*Triangular turnip-store.*

delay storing swedes until the end of February. There is, however, great risk of damage from frost, and it is safer to store the root early in winter before severe frosts set in.

When to Store White Turnips.—All white turnips, when allowed to remain on the ground after they have attained maturity, become soft, spongy, and susceptible of rapid putrefaction, which reduces them to a saponaceous pulp. This affords a good motive to store white turnips when they come to maturity, which is indicated by the leaves losing their green colour.

Turnips Consumed on the Ground by Sheep.—When different sorts of live stock are supported on the same farm, as is the case in mixed husbandry, the sheep are usually provided with the turnips they consume upon the ground on which they grow, which saves the trouble of carrying off a large proportion of the crop. The proportions carried off are not taken from the ground at random, but according to a systematic method, which requires attention.

One object in leaving turnips on the ground for sheep is, to afford a greater quantity of manure to the soil than it received in its preparation for the turnip crop; and as sheep can withstand winter weather in the fields, and are not too heavy for the ground, they are selected to consume them on it. This is a convenient method of feeding sheep, giving them their food on the spot, and returning great part of the food to the land in the form of manure.

Quantity of Roots to be left for Sheep.—The quantity of roots left upon the field to be consumed by sheep depends upon the weight of the crop, and whether the land is in a high state of fertility or not.

In ordinary practice on a mixed farm, worked on the five-shift rotation, at least one-half the crop will be required to be consumed by cattle to convert all the straw into manure. The other half may be consumed where grown by sheep, which are left in the manner described in the paragraphs which follow. When a small crop is the result of the growth of the season, the foregoing plan must be modified, and two-thirds or even a larger portion of the crop may have to be left for the sheep; but this will depend upon the soil, whether fertile or otherwise. However arranged, it must be always kept in view that cattle will thrive much better on artificial feeding than sheep, and that it is sound economy to give a certain portion of dry food, along with roots, to cattle and sheep, so that the proper ratio of nutrients be established, and every constituent of the food be economised and waste prevented.

Stripping Turnips.—When one-half of the turnips is to be left for sheep, the other half can be pulled in various ways, but not all alike beneficial to the land. It can be done by leaving 2 drills and taking away 2 drills; by taking away 3 drills and leaving 3 drills; by taking away 6 drills and leaving 6 drills; or by taking 1 drill and leaving 1 drill.

In ordinary farm practice, where half the crop is to be eaten off by sheep, the plan of taking 6 or 8 drills and leaving 6 or 8 drills is largely adopted, as in the other methods there is not sufficient space left clear of roots to allow a cart and horse to turn without damaging the roots.

The first break of turnip given to the sheep ought to be as large as possible, and therefore 8 drills should be taken and 4 drills left. This plan should also be adopted when it is desirable to leave a smaller quantity for consumption by sheep than one-half, which may be either due to a high state of fertility of the soil or to a short crop of turnips.

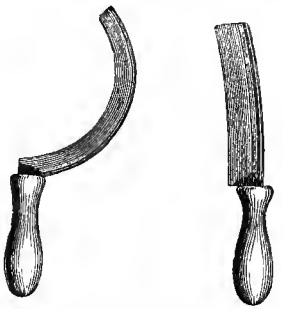
Whatever the proportion removed, the rule of having 2 or more empty drills for the horses and carts to pass along when taking away the pulled turnips, without injury to those left, should never be violated.

Turnip-tops as Food.—The tops of turnips possess greater value as manure than as food, and should therefore, as a rule, be left to be ploughed in on the ground. But when food for sheep is scarce, the tops may be given to ewes up to the latter end of December. This practice good farmers have for years pursued with excellent results, especially when given in conjunction with some concentrated food of a costive tendency, to counteract the laxative tendency of the turnip-tops. Cotton-cake is pre-eminently suitable for this purpose. Sheep are not so easily injured by turnip-tops as cattle, on account, perhaps, of their costive habit; but in the spring it is dangerous to let sheep consume them freely, as fatal results have often followed. Then many farmers have the idea that turnip-tops make good feeding for young beasts or calves at the beginning of the season—not from the knowledge that the tops really contain a larger proportion of bone-producing matter than the bulbs, as chemical analysis informs us, but from a desire to keep the turnips for the larger beasts, and to rear the young ones in any way. But such a notion is a mistaken one. No doubt the large quantity of watery juice the tops contain at this season makes young cattle devour them with eagerness on coming off perhaps a bare pasture; and indeed any cattle will eat the tops before the turnips, when both are presented. But experience favours the condition that the time in consuming turnip-tops is worse than thrown away, inasmuch as tops, in their cleanest state, are apt to produce looseness in the bowels of cattle as well as sheep, partly, perhaps, from the sudden change of food from grass to a very succulent vegetable, and partly from the dirty, wetted, or frosty state in which tops are often given to beasts.

Turnip-tops as Manure.—Tops are not thrown away when spread upon the ground—indeed, as already stated, they are more valuable as manure than as food, and should therefore, as a rule, be left to be ploughed in on the field. In systematic trials it has been found that from 2 to 3 bushels per acre more of corn was obtained when the turnip-shaws were ploughed down than when they were carried off the field.

Turnip-Lifting Appliances.—The

tops and tails of turnips are easily removed by means of very simple implements. Figs. 614 and 615 represent these in their simplest form, fig. 614 being an old scythe reaping-hook, with the point



Figs. 614, 615.—*Implements for topping and tailing turnips.*

broken off. This makes a light instrument and answers the purpose pretty well; but fig. 615 is better. It is made of a worn-out patent scythe, the point being broken off, and the iron back to which the blade is riveted driven into a helve protected by a ferrule. This is rather heavier than the other, and on that account removes the top more easily. Some prefer the implement seen in fig. 616. If the turnip requires any effort to draw it, the claw *c* is inserted gently *under* the bulb, and the lifting is easily effected with certainty.

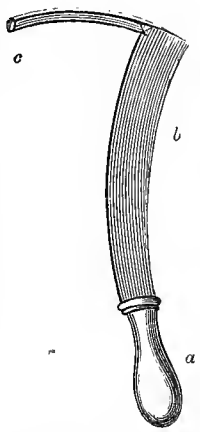


Fig. 616.—*Turnip-trimming-knife.*

a Handle.
b Cutting edge.
c Claw welded to the extremity of the back.

Mode of Pulling Turnips.—The mode of using these implements in removing tops and tails from turnips is this: When 2 drills are pulled and 2 left, the field-worker moves along between the 2 drills of turnips to be pulled, and pulling a turnip with the left hand by the top from either drill, holds the bulb in a horizontal direction, as in fig. 617, over and between the right hand drills, and with the knife first takes off the root with a smart stroke, and then cuts off the top between the turnip and the hand with a sharper one, on which the turnip falls into the row, the tops being thrown down on the cleared ground. Thus, pulling one or two turnips from one drill, and then as many from the other, the two drills are cleared from end to end.

Checking Turnip-growth in Spring.—It frequently happens, especially in spring, when the second growth of the turnips requires to be checked, that the ordinary method of pulling and cleaning the turnips cannot be quickly enough performed to prevent the crop becoming useless. More speedy means must therefore be adopted. The old style of slashing the tops off with a scythe or hook does not overcome the difficulty. The following method is pursued on some farms with a fair amount of success. A common scuffler is taken, and after the cutting part of the hoes is extended to about 12 inches, the hoes are reversed—that is, change the side, so that the cutting part is turned out instead of inwards. Operations may then be commenced, after fixing the body of the implement to the required breadth between the drills. The hoes cut the tap-root beneath the surface without disturbing the bulb, which remains in the position it grew. The growth is thus completely checked, and the bulb will remain fresh, as there is a sufficient number of the small roots left to provide the moisture lost by evaporation, but not enough for continued growth.

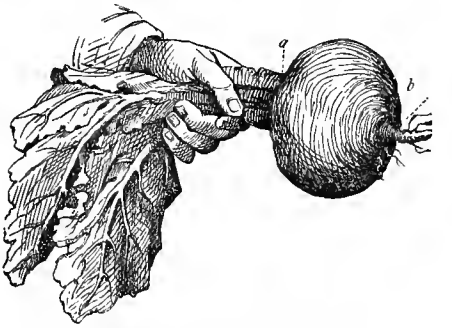


Fig. 617.—*Mode of topping and tailing turnips.*
b Root, first cut off. *a* Top, where cut off.

Many farmers run the chain-harrows across the rows, which leaves the crop lying on the surface, ready to store; but the bulbs require to be cleaned and partly trimmed before being used.

Turnip-lifters.—Implements known as "Turnip-lifters" are used to a considerable extent for topping and tailing turnips, but they are not as yet quite satisfactory in their working. The turnip-lifter would come into more general use if it were made to do the work throughout the season. When the shaws are strong and plentiful, these seem to clog the parts of the machine which top the turnips, and the coulter can seldom be set to cut away cleanly the spreading roots. With yellow and white turnips these machines often make excellent work, but as a rule they are not so successful with swedes.

Further Hints to Turnip-lifters.—Due care should be taken, on removing tops and tails, that none of the bulb be cut, as the juice of the turnip will exude through the incision. When turnips are consumed immediately, an incision does little harm; but slicing the bulb does much injury when the roots are to be stored for a considerable time.

Carting Turnips.—When the field is to be entirely cleared of turnips, the clearance is begun at the side nearest the gate; and if the workers move abreast, the carting on the land will be made as easy as possible. On removing prepared turnips from the ground, the carts are filled by the field-workers, as many being employed as will keep the carts agoing,—that is, to have one cart filled by the time another approaches the place of work in the field. If there are more field-workers than are required to do this, they should be employed in topping and tailing. The topped and tailed turnips are thrown into the cart by the hand, and not with ordinary forks or graips, which would puncture them. The cart is driven between the rows or lines of turnips, fillers being placed on each side. The carter manages the horses and assists in the filling, until the turnips rise as high in the cart as to require trimming, to prevent falling off in the journey.

Lifters one Yoking ahead of Carters.—It implies bad management to make horses wait longer in the field than the time occupied in filling a cart. It is well therefore to let lifters be one yoking ahead of the carters. The driving away should not commence at all until a sufficient quantity of turnips is prepared to employ the available carts one yoking; nor should more turnips than will employ the available carts for that time be allowed to lie upon the ground before being carried away.

Dry Weather best for Turnip-storing.—Dry weather should be chosen for pulling turnips, not merely for preserving them clean and dry, but that the land may not be poached. When so poached, sheep have an uncomfortable lair, ruts forming receptacles for water not soon emptied; for let land be ever so well drained, its nature cannot be entirely changed—clay will always have a tendency to retain water on its surface, and loam will rise in large masses with the wheels. Unless absolutely necessary, therefore, no turnips should be led off fields during or just after rain; nor should they be pulled at all until the ground has become consolidated. They should not be pulled in frost, and, as a rule, if they are urgently required from the field in frost or rain, a want of foresight is manifested either by the farmer or his manager, or by both.

On the weather proving unfavourable at the commencement of stripping, or an important operation intervening—as wheat-sowing,—no more turnips should be pulled and carried off than will suffice for the daily consumption of the cattle in the steading; but whenever the ground is dry at top and firm, and the air fresh, no opportunity should be neglected of storing a large quantity.

Importance of Storing Roots.—To store turnips in the best state should be regarded as a work of the first importance in late autumn or early winter; and it can be done only by storing a considerable quantity in good weather, to be used when bad weather comes. When a large quantity is stored, the mind remains at ease as to the state of the weather, and having a store does not prevent taking supplies from the field as long as the weather permits the ground to be carted upon with impunity, to be immediately consumed, or

to augment the store. No farmer would dissent from this truth; yet many violate it in practice.

Methode of Storing Turnips.—The storing of turnips is well done in this manner. Choose a piece of lea ground, convenient to access of carts, near the steading, on a 15-feet ridge, running N. and S., for the site of the store. Fig. 613 gives the form of a turnip-store or turnip-pit. The cart with topped and tailed turnips is backed to the spot of the ridge chosen to begin the store, and there emptied of its contents. The ridge being 15 feet wide, the store should not exceed 10 feet in width at the bottom, to allow a space of at least 2½ feet on each side towards the open furrow of the ridge, to carry off surplus water. The turnips are piled by hand up to the height of 4 feet, but will not pile to 5 feet on that width of base. The store may thus be formed of any length.

Thatching Turnip-store.—There are various ways of thatching turnips. In some cases straw drawn out lengthwise is put 6 inches thick above the turnips and kept down by means of straw ropes arranged lozenge-shaped, and fastened to pegs driven in a slanting direction into the ground, along the base of the straw. Or a spading of earth, taken from the furrow, may be placed upon the ends of the ropes to keep them down. The straw is not intended to keep out either rain or air—for both preserve turnips fresh—but to protect them from frost, which causes rottenness, and from drought, which shrivels them. Another method is merely to cover the roots with a layer of earth about 8 inches deep, and if care is exercised to see that the roots are quite dry before being covered, this system suits very well. To avoid frost, the end and not the side of the store should be presented to the N., which is generally the quarter for frost. If the ground is flat, and the open furrows nearly on a level with the ridges, so that a fall of rain might overrun the bottom of the store, a furrow-slice should be taken out of the open furrows by the plough, and laid over to keep down the ropes, and the furrow cleared out as a gaw-cut with the spade.

Turnips may be heaped about 3 feet in height, flat on the top, and covered with loose straw; and though rain pass through them readily, they will keep very fresh.

Turnip Pits in the Field.—In many cases turnips are speedily and effectually stored by being thrown into small heaps on the land, with from one to ten loads in each heap, and covered with earth. This method is called pitting, and is sometimes done without the aid of horses and carts. It is useful to place a tuft of straw in the apex of each pit as a ventilator.

Taking Roots from the Store.—When turnips are to be used from the store in hard frost, the straw on the S. end is removed, as seen in fig. 613, and a cart, or the cattleman's capacious light wheelbarrow, backed to it. After the requisite quantity for the day has been removed, the straw is replaced over the turnips.

Storing in Furrows.—One plan of storing is to pull the roots from one drill in which they have grown, and set them upright in the neighbouring drill, covering the bulbs with furrows. This plan, with slight alterations, has been followed in many parts of Scotland. Instead of leaving the tops, the bulbs are both topped and tailed. The plough returns in the furrow, opening up both sides as deeply as possible, and into this furrow the turnips from the drills at each side are thrown, the plough then covering up the whole. Turnips stored in this manner come out very fresh in spring, but can only be got out in dry weather, when a broad sock on a potato-lifting plough effectively brings them to the top, ready for cleaning by hand. It is a speedy and very effective method. But if there is any indication of an inclination of the bulbs to run to seed, this plan should not be employed.

Temporary Storing on Lea.—Another still more temporary method of storing is to pull the turnips and carry them to a bare or lea field, and set them upright beside one another, as close as they can stand, with tops and roots on. An area of 1 acre will thus contain the growth of 4 or 5 acres of the field. A turnip-field can be quickly cleared in this way for a succeeding crop. But

turnips cannot be so secure from frost here as in a pit or store; and after the trouble of lifting and carrying them has been incurred, it is much better to take them to a store at once, where they would always be at hand.

Storing in Houses Objectionable.—Defective as these temporary plans are, compared to triangular or flat-topped stores, they are better than storing turnips in houses, where they engender heat and sprout on the top, and seldom fail to rot. Roots should not lie in the turnip-house at the farm-steading more than two or three days at most.

Storing in Hurdle Enclosures.—The following method is frequently adopted for a temporary store. Ordinary hurdles are taken, and the spaces between the bars wattled up with the old straw ropes that have been used for thatching. These hurdles, when thus finished, are set with stays 9 or 10 feet apart, one of the ends being closed by a hurdle placed across. Into the enclosed space the turnips are backed in the carts and tilted, after which they are trimmed until about 3 feet high. The store may be made any length by adding hurdles; the whole being finished by throwing over the top old thatch, straw ropes, &c. Rain and air which permeate through the mass do no injury, but rather the opposite, as their tendency is to keep the turnips fresh and sappy.

Storing Turnips for Ewes.—A quick but rough-and-ready plan of storing turnips, when they are intended for ewes on the grass fields in spring, is coming more and more into favour in some districts. The turnips are pulled roughly, shaws and roots, and carted to a convenient corner in or near the grass field where they will be required, where they are simply tipped out of the cart as closely as they will lie. It is not possible to make the heap more than 3 feet deep by this plan, and therein seems to lie the success of the preservation. Hundreds of loads are often laid together in this way, and though they sprout a little, they usually continue in good condition, and the expense is not great.

Earthing-up Turnips.—The double mould-board plough is frequently employed to place earth upon the turnips in the drills, as a mode of temporary storing. The extra time required in pulling turnips after this process involves some loss, but the earthing-up protects the roots from damage by game and frost.

THE MANGEL CROP.

The mangel-wurzel, known more commonly as mangel, also as mangold, is embraced in the general term of "root crops." It belongs, however, to a race of plants quite distinct from the *Cruciferæ*, to which turnips and cabbages belong. The mangel cultivated on farms is the *Beta vulgaris* of the natural order *Chenopodiaceæ*. It is really a cultivated form of the wild sea-shore beet found in countries of the temperate zone. It was first grown as a garden plant, and it is understood that the field mangel was raised by crossing the red and white varieties of garden beet (*Beta hortensis*), the great development of root and distinctive features being obtained by persistent careful cultivation and selection.

It is believed that the field mangel was introduced into this country in 1786 by Thomas Booth Parkins, who obtained the seed in Metz. It is grown in the United Kingdom solely as food for stock. It is cultivated largely in France, Germany, and other countries for the production of sugar.

Varieties of Mangels.—There are many sub-varieties of mangels in use. The principal sorts are the long red, red globe, and orange and yellow globes. The last two are the hardiest, of excellent quality, with good keeping properties, and suitable to most soils in which mangels grow satisfactorily. The long red mangel is extensively grown on heavy soils, and produces great crops in favour-

able circumstances. They stand high out of the ground, and are therefore exposed to damage from early frosts. The red globe is better suited for lighter soils.

Climate for Mangels.—Mangels require different climatic conditions from those most favourable to turnips. Dry, hot summers are best suited to mangels. They thrive admirably, and yield a great weight per acre, in the southern counties of England and in the warmest parts of Ireland; but even in the best favoured districts of Scotland they are unreliable, and north of the Tweed are grown only to a very limited extent. Mangels stand drought much better than turnips.

Soils for Mangels.—Mangels need good soils. Thin poor soils, and the bleak, cold, high-lying lands upon which turnips luxuriate, are quite unsuited for mangels. Rich alluvial loams in high condition and well cultivated are best adapted for mangels, and they also grow well on strong lands in a warm climate, if these are carefully prepared and liberally manured. For the strong lands of the south of England they are better suited than turnips.

Cultivation for Mangels.—The preparation of land for mangels is in the main similar to that for turnips. And having already discussed so fully the various methods of autumn and spring tilling, cleaning, and manuring land for turnips, it will be unnecessary to do more here than point out wherein these practices should be varied to suit the mangel crop.

Autumn Tillage.—The great object to be aimed at in preparing land for mangels is to have it cleaned, dunged, and deeply ploughed in autumn. When the land is stiff these should be done as early in autumn as possible, generally before the end of October. Deep autumn ploughing is especially beneficial for mangels, and where the subsoil is inclined to form into a "pan," it should be broken up by subsoil ploughing.

It is a good plan, after the land has been thoroughly cleaned and deeply ploughed in September or October, to at once open drills, spread the dung, and cover in the drills just as at seed-time for turnips. Some recommend that before spreading the dung a drill-grubber should be run along to loosen the bottom of the drills. In these ridges the land lies throughout the winter, admirably exposed to the disintegrating influences of the season, and is found easily prepared for the seed next spring.

Spring Tillage.—When the land has been cleaned, ploughed, and dunged in drills in autumn, as just described, little has to be done in the way of tillage in spring. A light harrow is drawn along the drills (not across them), the drills are again set up by the drill-plough, and the seed thereupon sown. Such artificial manure as is to be given may be sown broadcast either before the harrowing or before the setting up of the drills.

When the dung has been simply ploughed in with an ordinary furrow in autumn, the land has to be grubbed and harrowed in spring just sufficiently to secure as fine a tilth as possible. Deep spring ploughing when the land has been dunged in autumn is not to be commended.

It often, perhaps generally, happens that a sufficient supply of dung is not available till well into the winter or early in spring. In this case the land is cleaned in the autumn and left in a strong furrow till early spring, when it is grubbed or ploughed, or both, then harrowed, drills opened—if the raised drill system is pursued—the dung spread, artificial manure sown, the drills closed, and the seed sown.

Strong land should be stirred as little as possible in spring. Mangels, like turnips, delight in a fine moist seed-bed, and it is difficult to obtain this with much stirring of strong land late in spring.

Drills and Flat Rows.—Mangels are sown both in rows on the flat and in raised drills. The latter is the better plan, as it affords greater facilities for the after tillage and cleaning of the land. The rows on the flat usually vary from 20 to 26 inches wide, and the raised drills from 25 to 29 inches. In dibbling, each hole should be about 1 foot apart, two or three seeds being placed in each.

Mangel Seed.—The seed of mangels is encased in a rough woody capsule which makes germination very slow, unless special means are taken to hasten

it. For this purpose the seed is steeped, for from 12 to 36 hours, before sowing —by some in warm water, by others in cold water, and by others again in liquid manure. If warm water is used, 12 to 14 hours should be sufficient. The seeds, when removed from the steep, are spread on a wooden floor, or on canvas cloth or sieve, and allowed to attain such a state of dryness as will prevent adhesion. In some cases the saturated seed is coated with a quantity of finely powdered charcoal, which is freely mixed with it.

The seed is then sown either by the flat-row drill or raised-drill machine, as the case may be. The peculiarities of the mangel seed necessitate the attachment of specially devised seed-boxes. Water or ashes may be sown along with the mangel seed, as in the case of turnips. The seed must not be put deeper in the soil than from ½ to 1 inch.

Quantity of Seed.—The quantity of mangel seed sown per acre is usually about 6 to 10 lb. If dibbled in, 3 lb. of seed per acre will suffice.

Time of Sowing.—Mangels have to be sown earlier than turnips. April is, as a rule, the best month for mangel sowing, but portions of the crop are usually sown earlier, sometimes even as early as February. When, owing to a crop of winter rye or some other catch crop occupying the land, or when, from some other cause, it cannot be prepared sooner, sowing may be done in May. After the middle of that month it would be very risky.

MANURES FOR MANGELS.

Dependency on Manure.—Mangels require, and will under favourable conditions repay, liberal manuring. It would be useless to attempt to grow them upon scanty fare.

They produce an extraordinary yield in a comparatively short space of time. To enable them to realise their full capabilities in this respect, an ample supply of the kinds of plant-food best suited to them must be furnished in a readily available condition. And the farmer must discriminate as to the kinds of plant-food to be supplied.

Ingredients absorbed by Mangels.—The following table, compiled from that on page 326, vol. i., shows the quantities of nitrogen, potash, and phosphoric acid—the three chief manurial ingredients—taken out of the soil by a crop of mangels weighing 22 tons of roots per acre:—

	Roots. lb.	Leaves. lb.	Total. lb. per acre.
Nitrogen . .	96	51	147
Potash . .	222.8	77.9	300.7
Phosphoric acid	36.4	16.5	52.9

Ingredients of Manure for Mangels.—These figures, compared with the corresponding analyses of a crop of turnips, show at a glance that the manurial wants of the mangel differ considerably from those of the turnip crop. Phosphates are essential for both, but do not by themselves exercise such a marked effect on mangels as on turnips. On the other hand, nitrogen, so little required for turnips, must be freely given to mangels. Then mangels will turn heavy dressings of good farmyard dung to better account than turnips can, while the palate of the mangel would seem to delight in having its food seasoned with a pinch of common salt.

Rothamsted Experiments—In Manuring Mangels.—Exhaustive trials in the manuring of mangels have been carried out and are still going on at Rothamsted. As to the results obtained, full information is given in the report on Rothamsted Experiments in this volume, pp. 28-32. The effects of different manures on the mangel crop there are shown clearly.

Salt for Mangels.—It is not in the least surprising that the application of common salt has been found in general farm practice to substantially increase the yield of mangels. The plant, we have seen, is indigenous to the sea-coast, and its ash is found to contain from 25 to 50 per cent of common salt. The late Dr A. Voelcker applied salt to mangels on deep sandy soil, and obtained an increase of 2 tons 6 cwt. per acre from 3 cwt. of salt; 5 tons 11 cwt. from 5 cwt. salt; and 4 tons 1 cwt. from 7 cwt. salt. Still, at Rothamsted heavy dressings of salt, over 5 cwt., were found to be hurtful rather than beneficial.

Useful Dressings.—In general practice farmyard manure is almost always applied for mangels. To obtain a maximum crop, and yet maintain the land in a high state of fertility, a fairly liberal allowance of dung may be regarded as essential — say from 8 to 12 tons per acre, though many farmers apply as much as 15 tons or more.

Still it has been shown in various experiments that in certain circumstances a mixture of artificial manures, consisting of from 3 to 5 cwt. of superphosphate per acre, 3 to 4 cwt. of sulphate of potash, 2 to 3 cwt. of common salt, and 2 to 3 cwt. of nitrate of soda, and perhaps a little rape-cake, might produce a fairly satisfactory crop of mangels without any farmyard manure. Some give kainit instead of sulphate of potash, and lessen the allowance of common salt.

Along with from 10 to 12 tons or more of dung a liberal allowance of artificial manure would be from 2 to 3½ cwt. of superphosphate, 2 or 3 cwt. of common salt, and 1 to 2 cwt. nitrate of soda or sulphate of ammonia. In many cases even larger quantities of artificial manures are applied; but with land in good average condition as to fertility these doses should, as a rule, be sufficient.

Basic slag has not, as a rule, done so well with mangels as superphosphate.

With a full allowance of dung there will seldom be much necessity for the application of special potash manure. If there is any reason, however, to suspect that there is a deficiency of potash in the soil, from 1 cwt. to 2 cwt. of kainit per acre should be applied.

As to whether it should be nitrate of soda or sulphate of ammonia which should be used along with the dung, the farmer must think for himself. He will especially consider the market price of the two commodities at the time, and buy whichever happens to be the cheaper. In a rainy climate and wet seasons sulphate of ammonia will most likely give better returns than nitrate of soda, and even in dry districts similar results are sometimes obtained.

The condition of the dung as to rottenness should also be taken into account in deciding whether to sow nitrate of soda or sulphate of ammonia. In well-rotted dung there is more readily available nitrogen than in fresh dung. With fresh dung, therefore, nitrate of soda would, as a rule, be preferable to sulphate of ammonia.

Dr Bernard Dyer, who has experimented largely on the manuring of mangels, places a high value on nitrate of soda as a manure for this crop. With less than 10 tons of dung he would give 3 or 4 cwt. of nitrate of soda per acre—one cwt. being sown with the seed, one cwt. as a top-dressing just after singling, and the remainder as a top-dressing some weeks later.[1]

APPLICATION OF MANURE FOR MANGELS.

It would be well here to refer to what is said in the special section on "Manures and Manuring" as to the general principles to be observed in applying the various manures to land—pp. 511-520, vol. i.

Dung.—If dung is available it should be applied in the autumn, and ploughed down or spread in drills, and covered in. If it cannot be applied in the autumn or winter, and if the mangels are to be sown in rows on the flat surface, the dung should be spread and ploughed in as early as possible in the spring. Where the mangels are to be sown in raised drills, and the dung cannot be applied till spring, it is spread in the bottom of the drills at sowing-time, as in the case of turnips — carted out and spread as described for turnips.

Artificial Manures. — Perhaps the most general plan is to sow these by the hand or machine in the drill or row at the time of sowing the seed, as for turnips. As a rule, however, it will be found advantageous to reserve the whole or part of the nitrogenous manure, especially nitrate of soda, and apply it as a top-dressing some time in July. The allowance of common salt is also by many held back till July, when some careful farmers apply a mixture of from 1 to 1½ cwt. of nitrate of soda, and 2 to 4 cwt. of common salt in two sowings.

There is no denying the advantage of such a top-dressing for mangels. It has been well established in extensive practice. By holding back the nitrate

[1] *Fertilisers and Feeding Stuffs*, p. 60.

of soda till the plants are ready to make use of its nitrate, loss by washing into the subsoil and drains is minimised.

Theoretically, one would expect that the slower acting sulphate of ammonia should give better results by being applied at the time of sowing, and this is the practice on many farms. Nevertheless, some farmers prefer to use it as a top-dressing—prefer it to nitrate of soda for this purpose also. These are points as to which hard-and-fast lines cannot in all cases be followed.

THINNING AND AFTER CULTIVATION.

Preliminary Cleaning. — Mangel plants are slower in growth at the very outset than are those of turnips. To keep down weeds, therefore, it may be necessary to horse or hand hoe the rows or drills before the plants are ready for thinning. This preliminary hand-hoeing need be resorted to only in narrow rows on the flat, or where weeds are encroaching injuriously upon the plants. The horse-hoe or drill-scarifier will suffice, as a rule, in raised drills.

Thinning. — As soon as the plants show a fairly strong leaf, they should be thinned and hand-hoed as in the case of turnips. From 12 to 14 inches are common intervals between the plants. The narrower the drills, the greater should be the interval between the plants in the rows.

As with turnips, it has been found that mangels of medium size usually contain more solid nutritious matter than mangels of excessive size. And by moderate, rather than large, intervals between the plants, the maximum yields of good food per acre are likely to be obtained.

After Hoeing. — The treatment of mangels after thinning is, in regard to hoeing by hand and horse-power, very similar to that of turnips. The horse-hoe or scarifier should be kept at work as long as the leaves of the roots will permit.

Transplanting Mangels.—The young mangel plant may be successfully transplanted. Blanks in the rows should be filled up by transplanting. This should be done with care, so that the tap-root may be dibbled right down into the soil. Unless the weather is showery at the time or the soil moist, the transplanted plants should receive a spray of water.

Mangels of exceptional weights have been grown experimentally from plants raised in a seed-bed (sown in January), and planted out in February. How far this system could, with advantage, be extended into farm practice is uncertain.

Injuring Mangel Plants. — Mangels are peculiarly liable to suffer from injuries to the leaves of the plants. Cuts or bruises to the leaves, even if inflicted when the plants are very young, do not heal up as would be the case in turnips — they remain as open, "bleeding" sores, robbing the plant of not a little of its life-juice, and rendering it liable to ready attacks of frost and decay. In the thinning of mangels, therefore, the plants should be guarded with the greatest care.

Yield of Mangels. — The yield of mangels per acre varies greatly. A good average crop should yield about 18 to 20 tons per acre. Sometimes it is as low as 12 tons, and occasionally over 40 tons per acre. In favourable years crops of from 25 to 35 tons are not uncommon.

Mangel Plagues. — Mangels suffer less than turnips from fungoid and insect plagues. See chapters in this volume on crop plagues.

STORING MANGELS.

The storing of mangels requires greater care than the storing of turnips. Pulling usually begins in the third week of October, and it is well not to pull more at a time than can be put into "clamps" (heaps) in one day.

Cover with Dry Straw.—Opposite opinions are expressed as to covering. Upon the whole, it might be safest to cover with dry straw or bracken. Special care, however, must be taken to see that the material used for covering is perfectly dry.

Pulling Mangels.—In pulling mangel-wurzel, care should be taken to do no injury to the roots. Cleansing with the knife should on no account be permitted: rather leave some earth on the

root. The drier the weather is, the better for storing the crop. The roots are best prepared for the store by twisting off the top with the hand, as a mode of preventing every risk of injuring the root, though little damage may be done if the knife is only used to cut off the top, and that not too closely. Mangels not being able to withstand severe frost, should be entirely cleared from the field before its occurrence.

The best way of pulling mangels is where two drills are pulled by one worker and the adjoining two drills by another, and the prepared roots placed in rows in the hollow intermediate to the four drills, the leaves being also thrown into rows between the roots. The leaves thus treated, when intended to be fed either by sheep folded on land or carted off and thrown on pastures for cattle or sheep, are always clean and fit food for stock, which they are not when thrown over the land and trampled on. Mangels not pulled, and protected by the broad leaves, will stand frost (if not very severe) without injury; but a very slight frost will damage those roots which are pulled, therefore it is wise to store the roots as soon as pulled. If the leaves are not desired to be used as food, they may be scattered over the ground. Mangel-leaves can be given to cattle with greater freedom than turnip-leaves.

Carting Roots.—On removing any kind of roots, the cart goes up between two rows of pulled roots, and thereby clears a space at once of the breadth of eight drills. In this manner the work proceeds expeditiously, and with little injury to the land by trampling. To save the land still further, and also to lessen the draught to the horses, the carts should be driven up and down the drills and not across them, whether going with a load or returning empty.

Method of Storing Mangels.—A general practice is to form heaps of the roots on a base varying from 6 to 8 feet wide, the roots on the surface being packed with their crowns outwards. The heap is drawn to a narrow ridge which may be from 5 to 8 feet high. To guard against fermentation, a thick handful of straw should be inserted in the ridge every 6 feet: this affords ventilation and keeps the roots from heating. It is usual to thatch the heap with about 4 to 6 inches of straw, covered with 6 inches or more of earth, care being taken to leave the ventilators uncovered. Some farmers defer earthing the uppermost two feet of the heap for a month or two, so as to lessen the risk of injury by fermentation.

Mangels Stored in Houses.—Mangels can be stored in houses with greater safety than turnips. Many farmers store several hundred tons of mangels in a store-house at a time, and if the top of the heap is only loosely covered with straw no harm will be done by fermentation.

A Suffolk farmer says he stores his mangels in a barn formed of wood, the inside of which is first lined with barley-straw 18 inches thick, to protect the roots from frost, the heap of roots being 12 feet deep and 18 feet wide, and left uncovered on the top. He has pursued this plan for several years, and it has preserved them admirably up to March, or even longer.

FORAGE CROPS.

Forage crops may be defined as those which are grown for the sake of their leaves and stems, as distinct from crops grown for seeds and roots. Chief amongst the forage crops are the grasses and clovers. These have already been described, and here will be given some information regarding several other forage crops which may be grown to provide wholesome green food for farm live-stock. These are vetches, lucerne, sainfoin, rye, cabbages, rape, mustard, crimson clover, kidney-vetch, gorse or whin, buckwheat, maize, sorghum, and prickly comfrey. Sainfoin, lucerne, buckwheat, maize, and sorghum are confined to southern parts,

where the climate is mild; the others may be grown in almost any part of the kingdom.

Importance of Forage Crops.—The growing of forage crops, particularly of crops to be cut and used as green food, has not yet received from British farmers so much attention as it deserves. Our acquaintance with forage crops is still imperfect, and the extent to which they are capable of contributing to the saleable produce of the farm is not fully understood or appreciated. In those districts of Britain where pasture does not succeed very well, or which are subject to severe summer droughts, the providing of a plentiful supply of green succulent food coming into use in succession all through the year is one of the greatest objects of the stock-owner. The forage crops at present in use, as they are now known and cultivated, are far from adequate for this purpose, and assuredly no subject could more worthily engage the attention or employ the resources of our great agricultural and experimental bodies than furnishing to farmers the knowledge and the means which would enable them to grow a more abundant supply of green food for stock throughout the year.

VETCHES.

The vetch or tare belongs to the natural order of *Leguminosæ*, and the cultivated tare or vetch is named *Vicia sativa*. There are numerous wild varieties.

The vetch is a most valuable forage crop. It is hardy and prolific, and affords palatable and wholesome food for stock. There are two varieties, the winter and the spring vetch. The former, through repeated sowing in winter, has acquired a hardiness that is quite remarkable.

Winter Vetches.—The winter vetch is sown to provide green food in spring before a full supply of grass is available. It is sown at various intervals from September till February where the climate is variable; in cold northern districts there is little use in sowing after severe winter frosts set in. It is a good plan to sow rye or oats along with vetches, so as to keep them from lodging and rotting at the root. Winter vetches should provide a good supply of food from April till June, according to the district.

The importance of having a supply of fresh succulent food at this season of the year, when roots are wholly or nearly exhausted, and before the pasture fields can sustain the animals, will be readily acknowledged by all farmers, and it is surprising that winter vetches are not sown much more extensively than they are, especially when it is remembered that they can be off the ground in time for a root or potato crop in the following season.

Spring Vetches.—Vetches should be sown at different times in spring, so as to afford a succession of cuttings when green food is likely to be most urgently required. If the weather and the state of the land permit, the first sowing may be made in February, and successive sowings may take place every second or third week up till towards the end of June. It is advisable to sow small breadths at a time, so as to have a succession of cuttings when the crop is in full bloom. By judicious sowings at different times in autumn, winter, and spring, supplies of fresh-cut tares may be had from the end of April till October.

Utilising Vetches.—In the colder northern districts vetches are for the most part cut as house food, chiefly for cattle, but partly also for horses, and likewise for sheep where the house feeding of sheep is pursued. In other parts the great bulk of the crop is consumed on the ground by sheep. In most cases sheep or lambs being pushed on for sale get the first run of vetches, store and breeding sheep following after and picking up what is left. Sheep are folded on vetches just as they are on rape or roots.

Vetches for Horses.—Horses eat vetches with a keen relish, and thrive well upon them. They should be provided for horses during the harvest work, and given in moderate quantities along with dry food. It is considered by many that on strong land there is no better or cheaper way of keeping farm-horses in summer than by feeding them in the stable or yards with vetches and a little dry food.

Land for Vetches.—Vetches usually

follow a grain crop. They thrive best on strong loams and tenacious clays, just the sorts of soil upon which turnip culture is most difficult. But they also afford a good return on lighter soils. In some cases vetches are sown upon strong land, which is fallowed in summer as a preparation for wheat. In other cases turnips or potatoes succeed winter vetches, so that the latter come in as a sort of "catch crop"—and a most useful one it is. Land for vetches does not require much tillage. If clean, ploughing, harrowing, and rolling will suffice. If the land should be foul, it may be grubbed and cleaned before being ploughed for the seed.

Seed.—The seed of vetches is usually sown broadcast, but often in rows about 8 inches apart. The quantity of seed varies from 2½ to 3½ bushels per acre, supplemented, perhaps, with from a half to a whole bushel per acre of oats or rye. Vetches are also sometimes sown along with rape. Vetch seed more than two years old should not be used. For growing the seed of vetches it is a good plan to sow vetches and beans together, at the rate of about half a bushel of vetches to 2½ bushels of beans per acre. The seed is harrowed in the same way as a corn crop.

Cutting Vetches.—Vetches are most valuable for feeding when cut just in full bloom, and before the seed has begun to form. It is thus important to sow small quantities at a time, so as to be able to use the crop as it comes into bloom. When vetches are grown for seed they are, of course, allowed to ripen, and are cut and harvested in the same way as peas.

Manuring Vetches. — Land for vetches may be easily and cheaply manured. If the land is in moderately good condition it may receive a light dressing of farmyard manure,—from 6 to 10 tons per acre,—which it is preferable to let lie on the surface for a few weeks previous to ploughing in. Along with the dung, or at any suitable time before or after dunging, 2 to 3 cwt. of kainit, and half that weight of superphosphate, should be sown over the unploughed land, and the same or more on the surface, as soon as the land is ploughed and before it is harrowed. Where the land is in good heart substantial crops of vetches may be grown with artificial manures alone, say 3 to 5 cwt. of kainit and 3 to 4 cwt. of superphosphate per acre. Like other leguminous crops, vetches can do much in the way of providing nitrogen for themselves.

Vetches and cleaning Land.—With a fairly liberal system of manuring, vetches seldom fail to do well in moderate seasons, and with a full crop they smother root-weeds well, while owing to the early cutting or eating of the crop, seed-weeds have no time to ripen their seeds. The land being bare comparatively early may be bastard fallowed and cleaned. Vetches, therefore, if well done to, offer an excellent opportunity of keeping down weeds, and of cleaning the land after the removal of the crop, thus leaving it in good condition for what is to follow.

LUCERNE.

In warm climates, notably in the southern counties of England, lucerne is a prolific forage crop. It is the *Medicago sativa* of botanists (Nat. Order *Leguminosæ*); root sub-fusiform, stem erect, flowers large and violet-coloured. Lucerne is said to have been brought to Greece from Asia. The Romans were well acquainted with its properties as a forage plant, particularly for horses. Hartlib endeavoured to introduce its culture into England in the time of the Commonwealth, but did not succeed.

Lucerne, though sometimes included in seed mixtures for rotation grass, is usually grown alone. When well laid down in suitable soil — deep calcareous loam, clean and in good heart—it affords every year several cuttings of excellent green food, which is relished by both cattle and horses. If kept free from weeds, the crop may remain productive for six or seven years. Weeds, however, are liable to disturb it, and may cause it to be ploughed up earlier. Land should therefore be prepared with great care for lucerne. It should be well cultivated, and as thoroughly as possible cleared of weeds of all kinds, and the crop responds to moderate dressings of dung and superphosphate. Occasionally the

year's produce amounts to 30 tons per acre, and 20 tons are by no means rare.

The seed is sown in April, in rows from 6 to 10 inches apart, at the rate of 20 to 30 lb. per acre. One cutting will be obtained in the autumn of the same year, but it is advisable to leave a rank growth to protect the roots from the winter's frosts.

The Crop for Dry Seasons.—Lucerne withstands drought wonderfully. It thrives best in a dry climate, and is therefore cultivated extensively on the continent of Europe. It is an exceptionally deep-rooted plant, and is thus comparatively independent of rain. The late Sir John Bennett Lawes found it the best of all the forage crops for a drought.

Lucerne is not well suited for extended cultivation in a wet climate.

SAINFOIN.

Upon the calcareous soils of the southern counties of England, sainfoin has proved a most useful and reliable forage crop. Belonging to the Natural Order *Leguminosæ*, it is the *Onobrychis sativa*, the cultivated sainfoin, of botanists.

Sainfoin Hay.—The sainfoin yields the finest quality of hay when cut before the blossom comes out. Jethro Tull declared this sanfoin hay, cut before blossoming, "kept a team of working store-horses, round the year, fat without corn, and when tried with beans and oats, mixed with chaff, refused it for the hay. The same fatted some sheep in the winter in a pen, with only it and water; they throve faster than other sheep at the same time fed with peas and oats."

Sainfoin, like lucerne, is a deep-rooted plant, and thrives best on dry soils in a dry warm climate. It is grown extensively, and with great success, on the chalky soils of the south of England. It is useful as an ingredient in mixtures for temporary grass and hay, but is perhaps still more valuable as a forage crop grown by itself.

If well laid down in clean suitable land, it will endure, and yield liberally, for six or seven years. It should not be resown upon the same land for some twenty or more years. Indeed it is a common saying that land will not successfully carry sainfoin more than once in a lifetime. Sainfoin is both cut and pastured, and especially for sheep a run of old sainfoin is much esteemed.

It is not a reliable crop on strong lands or in wet climates.

Land intended for sainfoin should be thoroughly clean and in good heart. The seed is best sown with barley or oats, and it may be mixed and drilled with the grain seed. In other cases it is drilled separately at the same time across the rows of the grain seed. The quantity of sainfoin seed used per acre is usually about four bushels of unmilled seed,—rough seed in the pod. Sainfoin does not develop fully until the second year, and it is therefore considered a good plan to sow from 6 to 8 lb. trefoil (*Medicago lupulina*) per acre along with it.

It would be well to defer grazing the sainfoin until after the first cutting has been removed. Young sainfoin is liable to be damaged by being grazed too soon by sheep.

RYE.

Rye makes a very useful forage crop. It is wonderfully hardy, and may be sown in autumn or winter for spring use as forage in northern parts, where even vetches cannot be depended upon. It throws up a rank growth, and although it is not so succulent as the vetch, it is, nevertheless, a valuable forage plant, affording, as it does, the earliest green food for sheep or cattle in spring. As already mentioned, it is often sown along with winter vetches.

For spring forage, rye should be sown in autumn immediately after the removal of a grain crop, at the rate of about 3 or 4 bushels per acre. If the land is in good heart, or the crop well manured with dung or superphosphate, and nitrate of soda or sulphate of ammonia, the rye will afford a large produce in the following April, when it may be consumed on the land by sheep, or cut and fed to cattle in the house.

In market-gardens at Biggleswade and other parts, strips of rye about 3 feet wide and 18 feet apart are grown to provide shelter for spring vegetables.

CABBAGES.

The cabbage (*Brassica oleracea capitata*, Nat. Order *Cruciferæ*) is a most suitable plant for field culture. It is not grown so extensively as might be expected, when one considers the vast amount of wholesome food which it is capable of producing.

The cabbage succeeds best on deep good loams, with porous or well-drained subsoil, and it also does well on well-farmed strong clays. It is a gross feeder, and requires liberal manuring and careful tillage.

There are three main groups of cabbage plants—(1) what are known as *early cabbages*, planted in autumn and ready for use next spring; (2) *summer cabbages*, planted in spring and consumed early in summer; and (3) *late cabbages*, planted in spring or early summer, ready for use in autumn and winter. The late cabbages are grown the most largely on farms: before dealing with the culture of these a few notes may be given regarding the raising of the earlier sorts, which are the varieties most extensively cultivated in family and market gardens.

Early Cabbages.

For Spring Use.—For the varieties fitted to withstand the winter and be ready for earliest use in spring the seed is sown in a carefully prepared seed-bed about two months before the permanent planting is to take place in autumn. The land for this variety must be in good heart, free from weeds, and fairly firm, a very loose soil not being well suited for holding the plants during winter. In the way of tillage, therefore, a shallow ploughing and slight harrowing will suffice.

The earliest cabbages do best on land well dunged for the preceding crop, the direct manurial dressing consisting of from 3 to 6 cwt. per acre of nitrate of soda, or partly nitrate of soda and partly sulphate of ammonia. This allowance is given as a top-dressing after the plants begin to grow in spring, and part of it is spread round each plant, not nearer the root than about 2 inches, and not farther away than about 5 inches.

For the planting of early cabbages the land is marked off in lines about 15 to 18 inches apart on the flat with a plough or other implement. In these lines the plants are put in with the dibble at intervals of from 12 to 15 inches. To keep the land clean a good deal of hand-hoeing has to take place.

The earliest cabbages are largely used for table consumption, and the main object of the grower is to have the crop as early in the market as possible.

For Summer Use.—The varieties of cabbages to be planted in spring for use early in summer are for the most part grown on land which has been well cultivated in the preceding autumn and winter and formed into drills. A fairly liberal allowance of dung—10 to 15 tons—is given in the drills, and this is supplemented by from 1½ to 3 cwt. each of kainit and superphosphate per acre, applied on the top of the dung.

The plants are dibbled on the top of the drills, and in order to get a firm hold for the plants the drills should be rolled with a drill-roller, such as that shown in fig. 584, p. 307 of this vol.

When these plants have started into vigorous growth they should get a dressing of nitrate of soda at the rate of about 2 cwt. per acre applied round the plants as already indicated. Three or four weeks later another similar dressing of nitrate of soda should be given.

By repeated horse-hoeing weeds must be thoroughly kept down.

Crops of cabbages thus treated should be ready for use early in July.

Late Cabbages.

As already stated, it is the late cabbages that are most largely grown as a field crop. For the information which follows on the culture and utilisation of field-cabbages we are mainly indebted to Mr John Speir.

Probably no ordinary farm green crop admits of growth in a moderately successful way, in a greater variety of soils or climates, than Drumhead cabbages. With suitable manuring they may be grown on sand, loam, or clay, and on the sea-shore, or well up the mountain-side.

Sowing and Planting.—The seed should be sown in a seed-bed early in autumn, and the plants transplanted

from it to the field in spring. Spring planting may be done in any suitable weather during March or April, the best crops being usually obtained from the earliest plantings, all other things being equal. By planting moderately early few plants fail to catch root, and as they are rarely hurt by frost after being planted out, they have thus a much longer season in which to mature a full crop.

The drills should not be less than 28 or 30 inches in width, and the plants about 1½ ft. apart in the drill. Planting is best done by the dibble, although some people prefer the spade.

Cabbage Plants.—About 1½ to 2 lb. of seed sown on 2 square roods of land should yield sufficient plants for an acre of the crop. The seed should be sown from six to eight weeks before the plants are to be planted out. For the most part, farmers purchase cabbage plants from market-gardeners or others who make a speciality of the growing of them. From 8000 to 10,000 cabbage plants are required to plant an acre.

Produce.—The produce of cabbages on good land under liberal and skilful treatment may reach from 30 to 50 tons per acre.

Manuring.—Where possible, cabbages should always have their farmyard manure applied to them in the drill. The cabbage is such a gross feeder that it is almost impossible to spoil it by excessive manuring. Any available quantity of farmyard manure, from 20 tons per acre upwards, may therefore be applied, and whatever assistance the crop afterwards requires can be made up by surface manuring with artificials.

As soon as the plants have thoroughly taken with the ground, and have begun to spread their leaves across the drill, they should receive from 1 cwt. to 2 cwt. of nitrate of soda or sulphate of ammonia per acre. For a first manuring this is best applied by dropping a little at the root of each plant, 1 cwt. doing as much good at this date, applied in this manner, as 2 cwt. applied broadcast, the plants being so far asunder that a large proportion of such a soluble manure sown broadcast runs to waste.

Before the crop is earthed up for the last time, it is always advisable to apply 1 cwt. or 2 cwt. of nitrate of soda or sulphate of ammonia, no matter how much manure may have been applied in the drill. This may either be dropped near each plant or sown broadcast, after the drills are grubbed and before the crop is earthed up. By this means the whole nitrate is turned over on the top of the roots of the plants and under their wide-spreading leaves, so that it is protected from washing, no matter whether the season prove wet or dry. Manured in this way, an enormous crop of cabbages can be grown almost any year, on nearly any kind of land.

Few who have not seen a crop thus manured can form any idea of the weight which may be produced, even under unfavourable circumstances; and certainly for autumn consumption no other crop will produce anything like the same weight of leaves and of an equal feeding value.

Dr Bernard Dyer recommends from 4 to 6 cwt. of nitrate of soda per acre for cabbages along with dung—the nitrate to be sown in successive doses at intervals of a few weeks.

Utilising Cabbages.—Cabbages are well suited for consumption by any kind of farm stock, but for dairy cows, lambs, or older sheep, they are particularly valuable. They are usually given to the cows raw, although a few people give them boiled or steamed; this, however, is generally considered to be unnecessary. In ordinary seasons the Drumhead cabbage will be ready to use from the beginning of October till the New Year.

In consuming the crop it is always best to begin by using the largest and ripest cabbages first, as these are the ones to suffer most by frost. In the interval the smaller and greener ones increase considerably in size, and the labour so spent is doubly repaid by the better preservation of the crop, as the small green cabbages suffer little from even severe and protracted frost.

Cabbages and Italian Rye-grass.—Where early cabbages are grown for table use, a crop of considerable value is got in autumn from the second growths, and from Italian rye-grass sown broadcast among the plants after the last hand-weeding and before the crop is earthed up for the last time. If this course is

followed, it is better to earth up the crop with a drill harrow and plough, which will not only mix the seed with the soil, but also cover the bulk of it. This crop makes little progress during the period that the main crop is in full growth, but as soon as it is removed the Italian rye-grass comes up quickly and soon covers the ground. This class of a cabbage crop is generally consumed during July and August, and after the main crop is removed the waste cabbages, second growths, and Italian make excellent feeding for sheep or lambs. So utilised, this catch crop may, according to season and situation, be worth from 40s. to 80s. per acre. It has also the further advantage of helping to keep down annual weeds, and conserving in its roots the excess of nitrogen which it is necessary to apply to the cabbage crop. Along the sea-shore of the southern counties thousand-headed cabbages may be grown after early potatoes. Those come in very handy in spring for feeding ewes and lambs, when other green food is extremely scarce.

Cabbages are usually regarded as an exhausting crop. This, however, is only partially true. Certainly, as already stated, they are gross feeders, and require heavy manuring; but if they are consumed on the farm the exhaustion does not arise.

Storing Cabbages. — Cabbages are generally consumed direct from the ground in a green state. They are not so easily stored for future use as are turnips or mangels; still there are some methods by which they may be safely preserved for several months. The mistaken idea that cabbages cannot be successfully stored or protected from frost except in a barn or other building specially prepared for them has, no doubt, prevented the more extensive cultivation of this most useful crop.

Amongst the various methods of storing cabbages which have been practised and recommended are the following: Taking them up and replanting them in a sloping manner, and covering them with straw; pitting them; hanging them up in a barn; turning them head downwards, and covering them with earth, leaving the roots sticking up in the air. But every one of these plans is attended with great labour, and some of them forbid the hope of being able to preserve any considerable quantity.

A plan which has proved successful is this: Throw up a sort of ridge with the plough, and make it pretty hard on top. Upon this ridge lay some straw. Then take the cabbages, turn them upside down, and, after taking off any decayed leaves, place them, about six abreast, upon the straw. Then cover them, not very thickly, with straw, or leaves raked up in the woods, throwing here and there a spadeful of earth on the top, to keep the covering from being blown off by the wind. Only put on enough of straw or leaves to hide all the green, leaving the cabbage-roots sticking up through the covering.

Stored in this way, cabbages of all sorts will be found to keep well through the winter, and they are at all times ready for use. They are never locked up by frost, as often happens with those pitted in the earth; and they are never found rotting, as is often the case with those stored with their heads upwards and their roots in the ground.

The bulk of this crop is so great, that storing in buildings of any sort is not to be thought of. Besides, the cabbages so put together in large masses would heat and rot quickly. In some gardens, indeed, cabbages are put into houses, where they are hung up by the roots; but they wither in this state, or soon putrefy.

By adopting the mode of storing recommended above, however, all these inconveniences are avoided. Any quantity may be so stored, in the field or elsewhere, at a very trifling expense compared with the bulk and value of the crop.

Lifting Cabbages. — Some recommend the cabbages to be pulled up by the roots; others prefer cutting the stem close to the ground and leaving the root in the ground, which will throw up a fresh growth of leaf early next spring. These sprouts are most valuable for ewes in early spring. Where the sprouts are not desired for food, the better plan is to pull up the roots along with the cabbages, as the spring growth tends to exhaust the soil.

Utilising Cabbage-stalks.—In regard to cabbage-stalks after cutting off the cabbages, a farmer says: "I do not

get these 'out of the way as quickly as possible,' by shooting them into a ditch to rot and wash away, as is too often the case. I lay them thin to dry, and then clamp and char them for absorbing urine, and drilling with a compost drill, or broad-casting, where most likely to be advantageous."

Thousand-headed Kale.

This is another Brassica of the cabbage sort, which is much esteemed as food for sheep. This variety may be sown in rows on the flat about the end of April, on rich well-prepared land, at the rate of 4 or 5 lb. of seed per acre. It will produce a bountiful yield of excellent food for sheep in the autumn.

Transplanting Kale. — Thousand-headed kale gives the best return when the plants are raised in a seed-bed, and planted out like ordinary cabbage. For transplanting, the seed is sown in a seed-bed, early in August, and the plants are dibbled into well-prepared, well-dunged land in October and November. This should afford an abundant growth for folding in the following summer. If required, a moderate dressing of nitrate of soda would force on the growth of the plants. But this is a troublesome plan, and in many parts of the country it has been entirely given up, and the seed is sown in rows on the flat.

Consuming Kale.—Thousand-headed kale thus grown, may either be consumed by sheep being folded upon it, or by the heads being cut off and consumed by sheep on pasture-land. If by the first method, the stems are not too closely eaten or peeled by the sheep, the plants will throw out new leaves, and afford a supply of delicious green food in the following spring. In cutting off the heads the bottom leaves should be left, and by taking care not to injure the stocks by either eating or cutting, and not allowing them to run to seed, the plants will endure, and supply useful fodder for several seasons.

RAPE.

Rape (*Brassica napus*, Natural Order *Cruciferæ*) is grown to a considerable extent as autumn food for sheep in the fold. The main crop is usually sown in June, but small patches may be sown as early as April, to afford successive folds of green food as they may be required. Rape is usually ready for consumption about three months after being sown. If sown by the grain-drill, from 8 to 12 lb. an acre may be used, but if sown broadcast, from 10 to 16 lb. may be given. If it is intended to eat the crop when very young, half a bushel of Italian rye-grass may with advantage be mixed with the seed. The land should be well dunged, and a dressing of from 2 to 4 cwt. per acre of superphosphate along with the seed will be useful.

Rape delights in fen or peaty soils rich in vegetable mould. It is sometimes sown upon newly reclaimed peaty land, and consumed by sheep, thus helping to reduce the rough soil to a useful condition. In some cases rape is sown after an early crop of potatoes, and consumed early in winter.

Rape should be hand-hoed like turnips, but it is not so carefully thinned, although it undoubtedly affords the largest yield when the plants are thinned out to from 12 to 14 inches apart. Between the rows weeds must be kept down by the horse-hoe or drill-harrow.

Rape is sometimes sown along with vetches, the vetches being sown broadcast over the rows of rape. This mixed crop affords admirable green food for sheep. Rape is also, in some cases, sown in seed-beds, and planted out like cabbages. It is well suited for clay lands when it is sown early and consumed in summer and early autumn, when these lands will bear sheep without injury. Then the early removal of the crop admits of the land being prepared in good time for wheat.

In upland districts, where a grain crop is less desired than a good green crop for summer and autumn feeding, the rape is best sown broadcast along with the grass-seeds in spring. Broad-leaved summer rape is the best variety, and it should be sown at the rate of 16 lb. an acre, in addition to the usual grass-seeds and clovers. The rape and young seeds will be ready to feed by sheep in July, and will provide good feeding between then and the end of November. Moreover, the young seeds

will be much better than they would have been if sown down with a corn crop, while the land will be greatly enriched by feeding off the rape. This is an excellent plan to pursue in laying land down to permanent pasture. The sheep should not be folded on the young seeds, but the rape and seeds stocked at the rate of 8 to 12 sheep per acre.

Rape is known to possess high fattening properties. It is also highly stimulating, and is the best of all food for flushing ewes at tupping time. To lambs, and also to ewes in lamb, it should be fed in moderation, and along with hay or other dry food.

MUSTARD.

Mustard (*Sinapis alba*, Natural Order *Cruciferæ*) makes a very useful catch crop. It grows up very rapidly, being ready for consumption on the land by sheep in about eight or nine weeks after being sown. The white mustard may be sown in southern counties after an early corn crop, about a peck of seed being sown broadcast. It is sometimes also sown in spring before a late crop.

Mustard is very sensitive to frost, and should therefore be consumed before the end of October.

In many cases it is sown to be ploughed under as a green manure. For this purpose it is also very useful. Besides affording useful manure itself, it helps to prevent the waste of nitrates, which, instead of being washed away in drainage-water —which would probably happen if the soil were bare — are stored up in the growing plant.

SOWING CRIMSON CLOVER.

The crimson clover (*Trifolium incarnatum*) is one of the most beautiful plants cultivated in the field. Its stem rises up to 2 feet or more in height, with spikes of tapering, nodding, brilliant scarlet-coloured flowers. It was long cultivated in the garden as a border annual. It is an excellent forage plant, and when sown in autumn, so quick is its growth that it affords the earliest cutting in spring of any plant of its age. In Scotland it is useless to attempt its cultivation except as a garden plant, damp autumns and winter frosts never permitting it to come to a good result. It is successfully grown in some parts of Ireland.

Culture in England.—Trifolium is grown largely in the south of England. It produces the best results on soils of a loamy nature; but on thin, poor, high-lying land the plant appears quite out of place.

Of all known plants it is best suited for the stubble of a cereal crop in England. It may either be drilled in summer in rows of from 8 inches to 1 foot distant, or sown in autumn broadcast on stubble, and covered by harrowing. From 20 lb. to 28 lb. of seed are sown per acre broadcast; and the quantity is increased or lessened according to the nature of the climate and soil. From the beginning of August till the first week of September is the best time to sow.

Crimson clover ripens its seed easily in England; and English seed of the first year after importation is the best, being heavier and more free of the seeds of weeds than the foreign seed.

As a Forage Crop.—When sown in autumn, the entire crop may be grown, cut down, and cleared off by June following, allowing the ground to be worked up for late turnips, to be consumed in autumn. When cut in full flower, it makes hay much relished by horses, and its entire yield may be nearly twice the weight of a crop of red clover. It is better suited to sow on stubbles than even the white turnip. It is more rapid in its growth than winter tares. On light land a crop of buckwheat may be readily obtained after it. Italian rye-grass may be sown with it, and will grow as rapidly. After the crimson clover has been cut, the rye-grass will continue to grow and afford an excellent second crop.

The crimson clover, having the property of smothering early weeds, is not well suited for sowing among a corn crop.

Late Variety.—A variety of crimson clover named by the French *tardif*, or late-flowering, was introduced to notice in France about 1836. If sown at the

same time as the common variety in autumn, it will flower next season after that has yielded its crop, and thus form a valuable successor. Its characteristics are lateness of flowering and tallness, with vigour of growth.

Extra late Variety.—A few years ago Messrs Sutton & Sons, of Reading, introduced another variety, called Extra Late Red (*Trifolium incarnatum tardissimum*), which usually comes in from ten days to a fortnight after *T. tardif*, thus prolonging the supply of this valuable forage crop up to midsummer. The Extra Late Red has a special value on account of its suitability for filling up deficient clover leys, as if sown after the corn is off it is ready for cutting with the clover sown in the previous spring.

White Variety.—A fourth variety, with white flowers (Late White Trifolium), which comes in about the same time as *T. tardif*, is also spoken of favourably by some growers.

ITALIAN RYE-GRASS.

Italian rye-grass (*Lolium italicum*), growing rank and quick, is not so well suited for sowing among a corn crop as by itself when used as a forage crop. Its nature certainly indicates that it is better adapted for a forage than a pasture plant.

Sowing for Forage.—As a forage crop it should be sown by itself in a portion of the dunged fallow land in August, or the middle of September at latest, that it may acquire sufficient strength to stand the winter. It may be sown broadcast, there being no use of drilling it, since it will grow as early in spring as any weed, and will outstrip it in growth.

Seed.—On account of its natural tendency to produce many stalks from the same root, and its upright habit of growth, not forming a close turf, the seed should be sown at the rate of from 1½ to 2 bushels per acre. If sown in August or early in September, the seed should be well harrowed in, as the plants stand the winter better when the roots are moderately well covered. The seed germinates well at 1 inch to 1¼ inch deep.

If the ground and weather are dry in spring, the roller should smoothen the surface.

Produce.—The crop will be ready for cutting in May, and yield from 3 to 5 tons of forage per acre.

Irrigation Crop.—Italian rye-grass is an extremely valuable crop for irrigated land. It is in general use on sewage farms throughout the country. For this purpose one seeding will generally last two years, one-half of the land being ploughed up and reseeded every year. Under sewage cultivation the same land may be resown with Italian rye-grass as often as is thought desirable, as when one crop follows another in that way, the crop does not seem to suffer in any degree from disease or other cause.

OTHER FORAGE PLANTS.

Furze, *gorse*, or *whin* (*Ulex europœus*, Natural Order *Leguminosœ*) as a forage crop will be referred to in the section Food and Feeding in vol. iii.

The kidney-vetch is regarded by some as a useful forage plant. Professor Wrightson thinks it worthy of a trial, and says that it ought to form an ingredient in mixtures of permanent pasture seeds intended for light and thin soils, in which this plant finds its most suitable position.

Maize and *sorghum* are both recommended as forage plants for southern counties, but they have not been largely grown. They are unsuited to northern districts.

Regarding the merits of *prickly comfrey* (*Symphytum asperrimum*, Natural Order *Borragineœ*) as a forage crop there is much difference of opinion. For odd corners it is of some use. It requires heavy manuring. It is perennial, and the plants are dibbled in 18 inches apart, in rows from 18 inches to 2 feet apart.

Buckwheat has also a certain value as a forage crop. It is very susceptible of injury from frost, and can seldom be sown with safety earlier than May.

HOP CULTURE.

The hop is the most speculative of all the farm crops grown in the United Kingdom. Its produce varies from little more than 2 to 20, or perhaps even 25 cwt. per acre, worth from less than the cost of picking to upwards of £20 per cwt. The more usual prices run from 50s. to £5. The area under hops in England has varied greatly. At one time it exceeded 70,000 acres, but with lower prices, due mainly to the importation of hops, the growth of the crop has diminished to a large extent. Many fortunes have been made and lost in the growing of this crop, around which has gathered a halo of romance which hop-farmers delight to contemplate and talk of.

The hop requires a fine climate and good land. Its cultivation in this country is confined mainly to the English counties of Kent, Surrey, Sussex, Hampshire, Worcestershire, and Herefordshire.

One feature of the agriculture of the principal hop-growing districts is, that the hop may be almost said to monopolise the attention of the farmer, with the result that the other crops of the farm occasionally suffer.

The hop (*Humulus lupulus*) belongs to the class and order *Dicœcia Pentandria* of Linnæus, Natural Order *Urticaceæ*. It is generally believed that the hop was introduced into this country in 1524.

Varieties of Hops.—No fewer than about 160 varieties of hops are said to be in culture throughout the world. In this country only a small number are in regular cultivation, the principal of these varieties being — Goldings, Bramlings, Grapes, Jones, Farnham Whitebines, Mathons, Cooper's Whites, Fuggles, and Colegates. The Golding is generally acknowledged as the best variety in this country, but for certain localities other sorts are more suitable.

The selection of the most suitable variety for a given locality and soil requires considerable experience and good judgment. Whichever kind is chosen, it is desirable either to have only one variety within one hop-ground, or the varieties separated in the same ground. Different varieties require to be pulled at different times. It is desirable, in choosing different varieties, to have them to ripen in succession, in order that the hops may not all be ready for picking at the same time.

Male and Female Hops.—The male and female being on separate plants, there has been a good deal of discussion as to the necessity or desirability of planting male plants so as to ensure fertilisation. It is contended by many that there should be at least one male plant on each acre of hops. But in practice no attention is paid to this. The male plants are generally grubbed up, and the fertilisation of the female plants left to chance.

Soil for Hops.—The soil for the hop plant should be deep and mellow, and if resting on a fissured rock, so much the better. An old meadow forms the best site for a hop-ground. In every case the ground should be dry—not subject to stagnant water, and, if not naturally dry, it should be made so by thorough drainage. To afford sufficient room for the roots of the plants, the drains should be not less than 4 feet deep, and the distances between them from 15 to 35 feet, according to the tenacity of the subsoil.

Preparing Land. — Land which is about to be planted with hops is either trench-ploughed or trenched by hand in the autumn before planting. In the former practice the land is ploughed deeply with an ordinary plough, followed by a subsoiling apparatus, to break up the hard bottom as shown in figs. 323 and 324, pp. 401 and 402, vol. i. If this plan is not thought advisable or practicable, then the land is dug by hand labour to the depth of two spades. It is considered a good preparation to fold sheep on the land and feed them well before ploughing or digging; and at the time of ploughing or digging a heavy dressing of farmyard manure is given.

Rearing Hop Plants.—Hop plants are raised from cuttings taken from the

"hills," or plant-centres, when these are being dressed early in spring. The cuttings are reared in a nursery until about the end of the autumn of the same year, by which time they have formed a strong root. These sets, or young plants, may be purchased from those who give special attention to their culture, and good judgment is required in selecting the kind best suited for each particular locality. Local experience is the best guide as to this, as well as in regard to many other points in farm practice. Attempts to raise hop plants from seed have not been successful, owing to the strong tendency of the plant to revert to its wild type.

Planting Hops.—The planting takes place either just before winter sets in or early in spring. The cuttings or shoots are planted in "hills," two or three to each "hill." Changes in the systems of training have involved modifications in the standard distances between the "hills." When poles were in vogue the "hills" were usually from 5 feet 6 inches to 6 feet 6 inches apart each way, but now the alleys are wider and the plants closer together in the rows. The common width between the rows under modern conditions is 6 feet 6 inches, while the "hills" are from 4 to 5 feet apart in the rows.

Since the fourth edition of this work was published, poles as a medium of cultivation have been very largely abandoned, their place being taken by a system of wire and string or coir yarn. In different districts variations of the wire and string arrangement are met with,—what is known as the Butcher system obtaining in some localities, while the umbrella and cross-over designs find favour in other parts. The principle is the same whatever the precise method adopted, and the net result is that the hops are trained on coir yarn instead of poles. The young shoots of the plant make much more rapid progress on string than on poles, and as a rule there is a stronger growth of bine, the main shoots reaching a higher point before throwing out laterals than when poles were used. The laterals as well as the upright bine are stronger, and spread over a larger surface when string is employed, and in this way the plants have a better exposure to sunshine and air, which conduces to the production of a larger crop of bigger and better developed hops than it is possible to grow on poles. It has been contended that the depreciation in the hop markets is largely due to increased production per acre, and if this is the case there is no doubt that the adoption of the wire and string system of training is chiefly responsible, for it has enabled growers to obtain a substantial increase in the average return of hops.

Cost of Wiring.—The cost of wiring an acre of hop land will run from £30 to £45 per acre, the price being influenced largely by the price of the posts or poles required for standards. If poles are plentiful and can be obtained within easy carting distance of the hop farm, the lower figure may cover the expenditure, but in a district where poles are difficult to procure and have to be brought from a distance, the outlay may easily reach the higher sum. At the lowest estimate 250 poles are required per acre. The outside or straining poles are usually 5 or 6 inches in diameter at the bottom, and the intermediate poles from 3½ to 4 inches in diameter. Larch fir poles are most sought after for the purpose, as they are generally straighter and last longer than other kinds. After larch, chestnut is perhaps the most suitable. The coir yarn used in training costs from £19 to £23 per ton, and about 2 cwt. is required per acre.

Where poles are used it is necessary that they be sufficiently strong and long to support the plants effectively. The best poles are of larch, ash, chestnut, willow, oak cut in winter, alder, beech, in the order enumerated.

The crop is not expected to give any produce the first year. In that season the ground between the hills may be utilised in growing potatoes, cabbages, or some such crop, though it is better not to do this, as the hop plants require a great quantity of manurial substance.

The hop land has to be thoroughly dug or ploughed every autumn or winter, the "spud"—a three-pronged fork or "graip" with broad points—being used for the former purpose.

Dressing Hop Plants.—Early in spring the adult hop plants are dressed

as soon as the soil is sufficiently dry to be worked satisfactorily. The old bines and fibrous growth of the previous year are cut away, and some fine earth is thrown over the "hills."

These are nice operations, and require an experienced hand to execute them, otherwise the success of the future will be rendered doubtful. Mr Rutley writes thus particularly on this subject—after stating that one boy or woman opens around the stock of the hill, with a small narrow hoe, a little below the crown of the hill—"one man follows with a pruning-knife and a small hand-hoe, with which he clears out the earth on the crown of the hill between the sets or shoots of last year that were tied to the poles; and which, from having earth put on them the preceding summer, swell out to four or five times their original size, and form what we call sets or cuttings; and it is the cutting them off at the right part that should be particularly attended to, or great injury may be done. It is therefore necessary that the person cutting them should ascertain exactly where the crown of the hill is, that he may not cut them too low or too high; and the place where they should be cut off is between the crown of the hill and the first joint, for it is around the set close to the crown where the best and most fruitful bine comes. If the set is pared off down too close to the stock or crown, it takes away the part from where that bine comes, as little buds are seen ready to shoot forth at the time of cutting, which, if cut off, the bines come weakly and few. On the other hand, if the set is cut off above the first joint, which sometimes will be the case if the man in cutting does not pay the attention to it he ought, the bines which come from that or any other joint higher up the set grow fast, but are coarse, hollow, or what we call pipy, and unproductive: all such should be discarded at the time of tying. Consequently the operation of cutting or dressing, on which the future well-doing of the plant so much depends, is not left so much to the judgment or skill of the operator as to his care and attention. Many planters have their hops dressed by the day, paying extra wages to persons in whom they can confide to do it with care. After all the old bine and runners, as the roots and small rootlets near the surface are called, are cut and trimmed off clean, some fine earth is pulled over the crown, and a circle made round with the hand-picker, to intimate where the hill is before the young shoots appear."

The dressing should be finished before the bines begin to show. Such of the sets as have two or more joints are selected to put into a nursery, or sold for that purpose. But the cuttings should be taken only from the most healthy bines.

The stringing operation follows. The strings are tied to the wires, three or four strings being placed to each "hill," and after the hop shoots have been served, two or three to each string, the remaining shoots are removed by cutting or by pulling out.

After Culture. — The vacant spaces between the "hills" must be well cultivated, kept free from weeds, and heavily manured. For the cultivation of the land a sort of horse-hoe, or "nidget" as it is called in Kent, is used.

In the month of June the "hills" are earthed up by the spade, and in some cases by the plough. After this, until picking, attention is confined to the cultivation of the vacant ground—that is, unless fungoid or insect foes attack the plants and demand serious treatment.

Manuring. — Hops are greedy for manure. The annual produce of a hop-ground consisting of hops and bines is very considerable, and as the perennial nature of the plant does not permit it to be placed in the category of those plants of the farm which follow each other in any given rotation, it is necessary to manure the ground at least once, if not twice, every year. The first manuring after the crop may be given in autumn or spring; and if in spring, the time is before the digging of the ground commences. The best plan is to apply the manure twice a-year: in the autumn or spring, with farmyard manure and woollen rags, and during the summer with some such manure as guano, rape-cake dust, and superphosphate of lime. Of farmyard dung, from 25 to 30 cubic yards should be given to an acre. Black mould is an excellent application about the crown of the roots. The dung should be carted on to the ground before winter ploughing or dig-

ging, and if applied afterwards, is drawn on to the land between the rows of "hills" in long narrow carts called "dollys" in Kent. Of woollen rags from 12 to 20 cwt. per acre; woollen waste or shoddy from 20 to 30 cwt. per acre; and guano rape-cake dust, and superphosphate of lime, 6 or 7 cwt. per acre, are convenient applications, in June and July, generally dug in closely around the "hills," and sometimes spread over the surface, and hoed in with horse-hoes or "nidgets." Mustard-cake makes a good manure for the hop plant.

There is difference of opinion as to the advisability of applying large dressings of nitrate of soda to hops. Many growers of wide experience are opposed to it, and at most do not give more than 2 cwt. per acre—1 cwt. in spring to push on the plants, and another cwt. about the time the bine is coming into burr to keep the hops in colour. With some growers it is a custom to apply 1 cwt. per acre any time before June sets in.

Experiments in Manuring Hops.—Dr Bernard Dyer and Mr F. W. E. Shrivell conducted continuous experiments on the manuring of hops for a number of years on the latter's farm at Golden Green, Tonbridge. They consider that, in the past, most growers have paid too much attention to supplying nitrogen and too little to the use of phosphatic manures. They recommend the use of superphosphate at the rate of 8 to 10 cwt. per acre annually for calcareous soils, or basic slag at the rate of 10 cwt. per acre annually for soils very poor in lime; or an alternation of the two manures for soils moderately poor in lime, or equivalent mixtures of superphosphate and bone-meal or guano. They also recommend 2 cwt. per acre per annum of sulphate of potash, except on soils naturally rich in available potash, or when a dressing of dung is used. In the presence of abundance of phosphates and potash, they find that nitrate of soda may be used to the extent of as much as 8 cwt. per acre year after year, in the absence of other nitrogenous manure, with advantage to the yield of hops and without detriment to quality. But they recommend that a variety of nitrogenous manure is also good, and that, therefore, a portion should be supplied as dung or as rape-cake, fish manure, or shoddy, in accordance with custom, but with the addition of nitrate of soda. Their experience, confirmed by observation on other farms, shows that even when the soil is otherwise liberally manured by autumn or winter dressings of dung or of rape-dust, fish guano, &c., 4 cwt. of nitrate of soda per acre, applied early in the season, may be regarded as a thoroughly safe dressing for hops, even in a season which turns out to be wet. This, however, is a dressing which, under these circumstances, it would be best not to exceed in the case of the more delicate varieties of hops. If neither dung nor any of the other ordinary nitrogenous fertilisers has been recently applied, there appears to be no reason to anticipate that 6 cwt. of nitrate of soda per acre would be otherwise than safe; while for freely-growing and heavily-cropping varieties as much as 8 cwt. per acre might be used. But a more general manuring, including a smaller quantity of nitrate of soda than this, will probably in the end commend itself to most growers.

Messrs Dyer and Shrivell advise that large dressings of nitrate of soda should be divided into separate applications of not more than 2 cwt. per acre each, with an interval of some weeks between the different dressings. The most favourable time for application on soils of medium consistency is probably April or May. For stiff or not readily permeable soils they regard this as the latest time at which, under normal conditions of weather, nitrate of soda should be applied, and they are inclined to prefer April to May for the final application.

But once again they urge that it should be borne in mind that neither nitrate of soda nor any other nitrogenous manure can be relied upon to produce a healthy growth and a heavy crop unless at the same time the soil is kept abundantly supplied with some form of readily available phosphatic manure, and also of potash, except on those soils on which it may have been experimentally ascertained that the latter is superfluous.

Creasoting Poles.—Hop-poles or standards are now universally treated with creasote at the ends, and this preparation makes them last about twice as long as before the practice was intro-

duced. The creasote, purchased at about 2½d. or 3d. per gallon, is poured into a tank into which the poles are set on end and kept there, sunk about 18 inches in the creasote for fully twelve hours. By this treatment the end of the pole which is stuck into the ground is rendered quite impervious to wet. There are three standard lengths of poles, 12, 14, and 16 feet.

Poling.—In most cases there are three poles to each "hill," but often only two, and in other cases the one "hill" has three poles, and the next only two. The two or three poles are set around each "hill" at equal distances apart. A hop-pitcher makes a hole deep enough to give the end of the pole a firm hold of the ground, which should be about as many inches in depth as the pole is feet in height. The pole is pushed down to the very bottom of the hole, and if it have any crook or set at the lower end, that is placed inwards, to be out of the way of the horses in "nidgetting" the ground; and the top should have a slight lean outwards, to give room to the bines to branch, and let in air and light.

Tying up the Bines.—Whenever the bines shoot to a length to be fastened, they are tied to the poles. In some seasons when the bine comes very early the coarser bines are pulled out. Three of the best bines are selected to be tied to each pole, and the rest are cut away. Withered rushes are used for tying; and the tie is made with a slip-knot, so that the tying may give way as the bines enlarge in diameter. The tyings are done from near the ground up to 5 feet above it, and when above that height ladders are used, which stand independently upon the ground. In the string system two or three bines are placed to each string. The bines do not require tying, as they cling to the coir-yarn. The tying begins about the end of April or beginning of May. From 18 inches to 2 feet of the lower end of the bines may be stripped of their leaves, to allow air to get to the crown of the roots.

Longevity of the Hop.—The power of some hop-grounds to produce a great crop year after year, when external circumstances are favourable, is extraordinary. Many grounds have borne crops for upwards of half a century, and some exceed in age an entire century. It must not be supposed from this, however, that any plant which had been planted at the formation of the ground remains alive such a length of time. Whenever a plant or an entire "hill" indicates symptoms of decay, it is removed and another substituted, care being taken to plant the same kind of hop as that cultivated in the ground.

Insect and Fungoid Attacks.

The hop is unfortunately subject to serious injury from various insects and fungi. As to these attacks, see the sections on Fungus and Insect Plagues on the subject in this vol.

Harvesting Hops.

Picking.—The harvesting of hops is really autumn work, yet the brief description to be given of the process may be conveniently introduced here.

Hop-picking usually begins about the last days of August or the first week in September. The picking is a tedious process, demanding the employment of a great number of hands. As a rule, the picking is done by bands of immigrants, men, women, and children, who wander to the hop-growing districts from large towns and villages. The process generally extends over three weeks, and the immigrant pickers live in extemporised villages, in huts, hopper-houses, or tents provided for the purposes.

The process of picking on the poling system was thus described by Sir Charles Whitehead, who did much by his writings to improve the practice of hop culture:[1]—

"The pickers are divided into companies of eight or ten, each of which is under the charge of a ganger or 'binsman,' who pulls up the poles for the pickers with wooden levers having iron teeth, called 'dogs,' and holds the 'pokes,' or sacks, or 'sarpliers,' for the measurer when he comes round to measure the hops that have been picked. In most cases the bines are cut about 2 feet from the

[1] *Jour. Bath and West of Eng. Agric. Soc.*, 1881, 208.

ground, and the poles are pulled by means of 'dogs,' or wooden levers with iron teeth, and carried to the pickers, who pick the hops from them into the bins or baskets. Occasionally when the hops are not quite ripe, or when the plants are weak, the poles are not pulled, but left standing. The bines are cut 4 or 5 feet high, and the bines with hops upon them are pushed up and over the poles with forked sticks, as bines cut high and kept to the poles in the upright position do not 'bleed' so much, or lose so much sap, as when cut short and left lying on the ground. The hop-grounds are marked out into as many portions or 'sets,' containing 100 hills, as there are companies, for which lots are drawn by each binsman, so that there may be no wrangling about good or bad sets. The hops are picked into bins — long light wooden frames with sacking bottoms. There is one of these for every two adult pickers. In Mid and West Kent and the Weald of Kent and Sussex, and in Worcestershire and Herefordshire, these bins are used. In East Kent large baskets are used for picking into, holding 15 to 20 bushels. In Hampshire and Surrey the hops are picked into baskets holding 7 bushels, which are emptied into long bags, called 'sarpliers,' holding 14 bushels, in which they are taken to the kilns. In Kent, Sussex, Worcestershire, and Herefordshire the hops are measured into pokes —sacks holding 10 bushels—in which they are taken to be dried. The measurer, who generally takes from six to eight companies, is accompanied by a boy, who enters the number of bushels picked into a book kept by each picker, and into a book retained by himself.

"The *price* of picking hops ranges from 1¼d. to 3d. per bushel. The average price is 2d. per bushel. Binsmen are paid from 2s. 4d. to 3s. per day. Measurers get from 4s. to 5s. per day. Driers, who work night and day, earn from £2, 10s. to £3, 15s. per week. Before picking commences, the planter generally fixes a price for picking. Sometimes it is not fixed until after a day or two, that it may be better ascertained how the hops come down."

The alteration in the system of training the hops has necessitated changes in the methods of picking. Whereas it was the usual practice when poles were in use to have the hops brought to the pickers at a given point, the latter now move from hill to hill until the whole plantation is completed, just as they would do in the pulling of any kind of fruit. There is the additional difference in the method of harvesting hops grown on strings from those grown on poles, that the former are not cut at the bottom, but are merely detached from the top wires and fall down within convenient reach of the pickers. In harvesting, as in other respects, the wire and string system is more convenient than that which it superseded.

Drying Hops.—Immediately on being picked, hops are artificially dried. They are dried in square or circular kilns, 16 or 18 feet square or in diameter, on haircloth, and heated by Welsh coal, coke, or charcoal. The kiln-floor is situate at 10 to 13 feet above the fire, and the height of the kiln is 18 to 20 feet above the kiln-floor, surmounted with a cap-cowl 7 or 8 feet in height and 3 or 4 feet diameter in the bottom, a free circulation of air being kept up through the fire and hops to the top of the kiln. The hops require to be rapidly dried to keep the pickers in operation. The kilns ought to take 1 bushel of green hops on 1 square foot of flooring, and be filled twice a-day, giving from 9 to 12 hours to each kilnful, so that from 200 to 250 bushels may be drying on one kiln at a time.

Artificial draught by means of fans, either exhaust or forced, is now largely used, and by its aid the foregoing quantities are easily more than doubled. Fans for exhaust, used in conjunction with the open fires, can be installed for a moderate outlay, and in all cases they should be placed as high up in the roof of the kiln as possible, as when they are high the heat is more evenly distributed over the floor than when they are placed near the haircloth or drying floor. Several systems of hot-air drying are in use. In most cases they are on the forced-draught principle—viz., a fan propelling air through hot-air furnaces or between coils of pipes heated by steam or hot water. This is claimed to be the ideal system for hop drying, as it allows only heated air to pass through

the hops, and thus prevents impurities that might arise from bad or inferior fuel coming in contact with the hops. It is only fair to say, however, that if the best anthracite coal is used in drying in the open-fire system the impurities are practically nil. The chief drawback to the use of hot air is the original cost. The average grower has difficulty in persuading his landlord, or himself, to expend a sum which may be roughly calculated at 10s. per square foot of drying space when hop-growing is a declining industry.

For two kilns of these dimensions, a cooling-room of 20 feet in width and 40 feet long is required. This should be on a level with the kiln-floor. And there should be another room of similar dimensions, under the cooling-room, for stowing and weighing the hops in the pockets.

Great caution is required to regulate the fires of the kilns. If too strong at first, when the hops are naturally moist, they will be drawn down to the haircloth and be much deteriorated in quality. The fire may be increased as the drying proceeds, until a temperature not exceeding 130° Fahr. is reached, and the drying process finished at a temperature gradually decreasing to 115° Fahr. About 13 cwt. of coal, with a little charcoal, will dry one ton of hops.

Sulphur is also used in drying hops, from ¼ to 1 cwt. to 1 ton of hops. The object of using sulphur is to improve the colour of the hops. It is of importance to the seller to present his hops in the market with a light-coloured delicate primrose hue.

When taken from the kiln, the hops are laid in heaps on the cooling-floor, not only to cool but to acquire a state of adhesiveness, which, though dry, causes them to lump together when squeezed in the hand, and yet not so much as to lose elasticity.

The drying will cause a loss equal to about three-fourths of the weight in a green state—giving 1 lb. of prepared for 4 lb. of green hops.

Pocketing. — Hops are put into pockets in the stowing-room, through an opening in the floor of the drying-room, under which the pockets are suspended.

A *pocket* is 3 feet wide and 7½ feet long, consisting of 5 yards of cloth, weighing 5 to 6 lb., and when filled contains 1 cwt. 2 qrs. to 1 cwt. 3 qrs. and a few pounds gross weight of hops.

Hops are packed in the pocket by powerful screw-pressing machines devised for the purpose. These presses, which are formed upon one principle, differing only in detail, were thus described by Sir Charles Whitehead:—

"A wooden circular foot, just large enough to go into a pocket 3 feet in diameter, is fitted to a ratchet lever, which is worked up and down by handles. This is fixed immediately over the 'pocket hole' cut in the floor. The empty pocket is fastened to a movable frame or collar, so as to keep its mouth firm to the floor while it is being filled, suspended in mid-air. There usually are two posts set up below, into which two rods, connected with a wooden stand, run up to hold the pocket up and to keep it straight. In place of these guiding rods, some pressers have circular iron cases to surround the pocket and keep it from bulging. Pressers cost from £14 to £27."[1]

The pocket is neatly sewn up, leaving a lug, or ear, projecting from each side of the sewn mouth.

The produce is then ready for the market.

Stacking Poles.—When the bines are cleared of the hops, they are taken off the poles, which are then put up in small conical stacks at equal distances apart on the hop ground, with the sharped ends on the earth, having four equidistant divisions striding over the "hills." Each division of the stack should be bound round with three bines, deprived of their leaves and twisted into a rope, which binds the division close and compact, and prevents the poles being stolen, or makes a theft more easily detected. The small refuse poles are bound together, separating those which may be used for the young bines of the first year from those which may be burned into charcoal, or used as firewood.

Analysis of Hops.—The quantity of mineral matter removed from the soil per acre by the different parts of the

[1] *Jour. Bath and West of Eng. Agric. Soc.*, 1881, 214.

Golding hop plant is, according to Way and Ogstone :—

	Flowers. lb.	Leaves. lb.	Bine. lb.	Whole crop. lb.
Silica	32.6	97.3	12.9	142.8
Phosphoric acid	29.5	40.6	15.1	85.2
Sulphuric acid	8.7	8.2	3.0	19.9
Carbonic acid	3.4	52.4	15.4	71.2
Lime	16.3	134.0	31.0	181.3
Magnesia	8.2	21.1	4.9	34.2
Peroxide of iron	1.1	0.8	1.0	2.9
Potash	54.0	57.0	22.9	133.9
Soda	...	...	...	...
Chloride of potassium	15.3	10.0	19.9	45.2
Chloride of sodium	1.3	13.6	3.4	18.3
Total	170.4	435.0	129.5	734.9

The hop plant is peculiar in the quantity of phosphoric acid required for all its different parts, as is seen above.

Spent Hops as Manure.—Spent hops are used largely for manure. The analysis of their ash, by Nesbit, is as follows :—

Potash	1.45
Lime	23.70
Magnesia	2.75
Phosphate of iron	2.50
Sulphuric acid	3.05
Phosphoric acid	4.10
Carbonic acid	9.00
Chloride of sodium	2.95
Chloride of potassium	0.70
Silica (soluble)	27.10
Sand and charcoal	21.80
	99.10
Percentage of ash	10.40

Cost of Hop-planting and Cultivation.—The planting of hops is very costly—generally about £24 to £25 per acre. The yearly outlay on the cultivation and handling of the crop is still more expensive. It usually runs from £35 to £45 per acre.

Produce of Hops.—The yield of hops varies greatly with the seasons, both in quantity and quality. It usually averages about 8 to 11 cwt. per acre.

FLAX CULTURE.

Flax (*Linum usitatissimum*, Nat. Order *Lineæ*) is cultivated for fibre or for seed, or for both. In the United Kingdom it is cultivated most largely in the north of Ireland, where it is grown with great success to supply fibre to the extensive linen-mills of Ulster.

With the exception of the scutching of the flax—*i.e.*, the separation of the fibre—the Irish farmers undertake all the processes connected with the crop, from the preparation of the land and the sowing of the seed to the selling of the scutched flax to the spinners.

In many other parts, notably on the continent of Europe, the farmer merely grows the crop and leaves its manipulation to others. In order to obtain the finest fibre, the flax has to be pulled before the bolls or seed are ripe. In Ireland the crop is grown for fibre alone, on the Continent for seed and fibre, and elsewhere almost solely for seed.

The flax plant is stated to be a native of Britain; and yet flax seed was not sown in England until A.D. 1533, when it was directed to be sown for the making of fishing-nets.[1]

Ure says of the flax plant: "In it two principal parts are to be distinguished—the woody heart or boon, and the *harl* (covered outwardly with a fine cuticle), which encloses the former like a tube, consisting of parallel lines. In the natural state, the fibres of the harl are attached firmly not only to the boon but to each other, by means of a green or yellow substance. The rough stems of the flax, after being stripped of their seeds, lose in moisture, by drying in warm air, from 55 to 65 per cent of their weight, but somewhat less when they are quite ripe and woody. In this dry state they consist, in 100 parts, from 20 to 23 per cent of harl, and from 80 to 77 per cent of boon. The latter is composed, upon the average, of 69 per cent of a peculiar woody substance; 12 per cent of a matter soluble in water;

[1] Haydn's *Dict. of Dates*—art. "Hemp and Flax."

and 19 per cent of a body not soluble in water, but in alkaline lyes. The harl contains, at a mean, 58 per cent of pure flaxen fibre, 25 parts soluble in water (apparently extractive and albumen), and 17 parts insoluble in water, being chiefly gluten. By breaking the harl with either hot or cold water, the latter substance is dyed brown by the soluble matter, while the fibres retain their coherence to one another. Alkaline lyes, and also, though less readily, soap-water, dissolve the gluten, which seems to be the cement of the textile fibres, and thus set them free. The cohesion of the fibres in the rough harl is so considerable, that by mechanical means—as by breaking, rubbing, &c.—a complete separation of them cannot be effected, unless with great loss of time and rupture of the filaments. This circumstance shows the necessity of having recourse to some chemical method of decomposing the gluten. The process employed with this view is a species of fermentation, to which the flax stalks are exposed. It is called *retting*, a corruption of rotting, since a certain degree of putrefaction takes place."[1]

Flax is manufactured into twine, rope, and thread, and into fabrics, varying in texture from coarse bagging, employed to pack cotton or hops, to canvas, linen, cambric, and finest lawn.

In former times the seed of the flax was occasionally used with corn to make bread, but it was found to be ill suited for the purpose, being difficult to digest.

As is well known, linseed, the seed of flax, possesses great value as an article of food for cattle.

Soil for Flax.—The flax plant thrives best on a rich kindly loam. On sandy soils the crop will not, as a rule, give a good yield of fibre. Good crops are often grown on clay land. Any soil in too high condition causes flax to be rank, branching, and coarse, and if the crop lodges the fibre will be deteriorated.

Rotation for Flax.—The finest flax is perhaps best obtained after corn. In the north of Ireland, where flax cultivation is pursued extensively and with great success, it is not considered good practice to grow flax after lea. It is difficult to get lea-land into a sufficiently fine tilth, and insect attacks are more frequent after lea than after oats. Flax does well after potatoes. It should not be repeated on the same land at shorter intervals than about seven years; some say nine years would be better still. Flat land is preferable to undulating, hilly, uneven land rarely producing flax of a uniform reed. The following is a general rotation in some districts in Ireland: 1st year, oats after lea; 2nd year, roots; 3rd year, oats; 4th year, flax with clover and grass seeds; 5th year, seeds hay; 6th and 7th years, pasture. In another rotation flax is taken between lea oats and roots. In both these cases, however, the flax is liable to be weedy, and some farmers prefer, therefore, to grow flax directly after the cleaning root crop.

Tillage for Flax.—After cereals, the land for flax should be ploughed early in winter, to receive the full effects of the frost. It cannot be in too fine a state of pulverisation when the seed is sown provided a firm seed-bed is secured. To promote this fine state of the soil, cross-ploughing should be executed early in spring, taking care to avoid wet weather, or the soil in a waxy state, as dry weather following renders the soil difficult to be pulverised. Clods left on the surface, after a double turn of the harrows, should be reduced by a clod-crushing implement.

The cross-ploughing in spring should be done about two months before sowing. Medium land after potatoes will do with one ploughing from four to six weeks before sowing. Heavy land after potatoes should be ploughed as early in the year as possible. Plough shallow, about 4 inches deep, after potatoes. It is recommended that as far as possible weeds should be removed by forks and graips in the preparation of the seed-bed. Flax delights in a firm, even seed-bed, and if the land is naturally dry or well drained, it thrives best broadcast or in rows on the flat. In drills it is more apt to be uneven in length, and it is very important that flax should be as uniform in length as possible. Light land should not be too much stirred, but heavy land cannot be too much pulverised.

Clod-crushers. — Crosskill's clod-

[1] Ure's *Dict. of the Arts*—art. "Flax."

crusher, shown in perspective in fig. 618, is a most efficient implement. The roller consists of a number of toothed wheels, supported on feathered arms, and

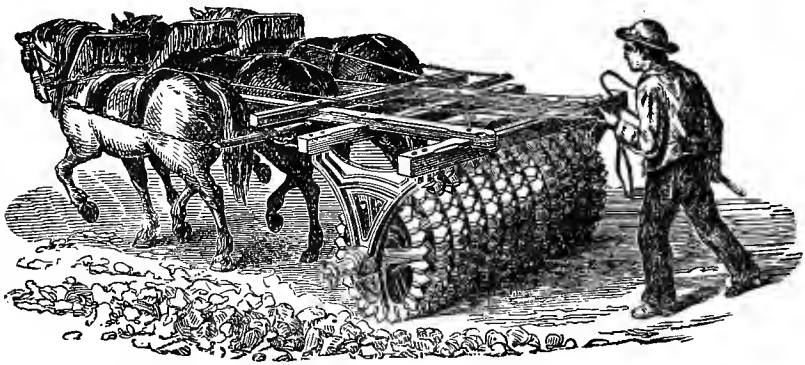


Fig. 618.—*Crosskill's clod-crusher.*

an eye formed in the centre fitted to move easily on the axle of the roller.

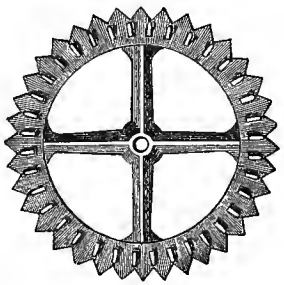


Fig. 619.—*Side view of one wheel of the clod-crusher.*

Fig. 619 shows a side view of one of those wheels, by which its action upon the soil may be easily understood.

This clod-crusher has been only slightly used by Scottish farmers, but it is extensively used in England to break down clods on strong clay soils.

Norwegian Harrow.—Another very useful pulverising implement is the Norwegian harrow (Clay), shown in fig. 620. The action of this machine is to reduce large clods into very small ones, by the insertion of the points of the rays into them, and to split them into pieces by their reiterated action. The larger clods are split into smaller pieces by the first row of rays, the second row splits these into smaller ones, and the third row splits those smallest pieces into still smaller ones; so that, by the time the clods have undergone those various splittings, they are probably sufficiently pulverised.

Spring-Tined Cultivator. — The

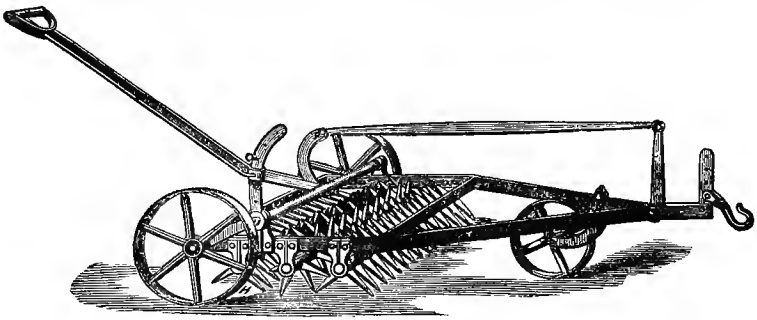


Fig. 620.—*Norwegian harrow.*

spring-tined cultivator, such as is shown in fig. 604 in this vol., is very useful in the preparation of a seed-bed. It is, in the long-run, quite as efficient as the Norwegian harrow, being, of course, of much lighter draught.

Sowing Flax.—The time for sowing flax will of course depend partly on the climate of the district and partly on the character of the particular seasons. As a rule, from the last week in March till the third week in April is the flax seed-time. The young flax plants, if the sowing has been done too early, are liable to injury from frost, which causes the plant to branch, thereby greatly lessening the value of the crop.

Prepare a fine, smooth, firm seed-bed with the harrow and roller. Some harrow, roll, and then sow; others harrow, roll, and harrow again, and then sow. The land may be marked off on the flat for the casts of seed with poles or foot-prints.

Seed. — Russian (Riga) and Dutch seed are most commonly used. Recent experiments have demonstrated that there is no foundation for the opinion held in many flax-growing districts, that Riga seed suits light soils and Dutch seed heavy soils. Good seed gives uniformly good crops on all classes of soil. Care should therefore be taken to secure pure seed, of high germinating power and a relatively heavy sample. A good average sample will be 98 per cent pure, show at least 95 per cent germination, and a thousand seeds or "pickles" will weigh 4½ grams. Riga seed is not usually so pure as Dutch, and at times, owing to the adverse weather conditions which have prevailed in the Continental flax-growing districts during the seed-harvest, very inferior samples of sowing seed are placed on the market. No pains should, however, be spared to secure good seed for sowing purposes.

As to the quantity of seed, if the crop is grown for fibre, 7 pecks (7 stones) of a sample conforming to the above figures will be required per acre; if for seed, a thinner sowing is advisable. Many samples of Riga seed do not, however, possess a germinating power of even 90 per cent, and are not 98 per cent pure. More seed will in such cases be therefore required. Flax-seed may be sown by a broadcaster, a seed-barrow as used for clover and grain, or by hand. If sown by hand, it must be done by a skilful person as the seed is very slippery. A strip with a light harrow will suffice to cover the seed. Flax seed is oblong, lenticular in shape, having a smooth oily surface, feels heavy, and should be plump and fresh. A most useful hand-broadcaster is that named "The Little Wonder," commonly called the fiddle sower, illustrated in fig. 424, p. 125, of this vol. Since its introduction this machine has become most popular in flax-growing districts of Ireland.

Grass Seeds with Flax. — Land is frequently sown out into grass with the flax crop. Italian rye-grass is injurious to the flax on account of its vigorous growth, but perennial rye-grass, clovers, and natural grasses may be sown. In a wet season, however, this is an objectionable practice, for the grasses deprive the flax of its nourishment. Such flax when scutched presents a brown "root"—*i.e.*, the fibre is browned at the base of the stem and its value accordingly decreased. The grass and clover seeds should be sown immediately after the flax seed, and the two harrowed in together with a light harrow. If it is desired to have Italian rye-grass after flax, the seed may be sown as soon as the flax is pulled, late in July or early in August.

As a catch-crop for districts where the climate is suitable, scarlet clover (*Trifolium incarnatum*) may be sown when the flax is pulled, and this will provide a useful cutting in the following May, after which the land may be prepared and sown with turnips. Others sow rape or winter vetches and rye after flax for spring food for stock.

Manuring Flax.—The flax crop does not bear being sown upon dung. The land should be in high condition from previous manuring. Recent experiments show that a potassic manure is to be recommended for this crop, particularly on lighter soils. A dressing of 4 to 5 cwt. kainit, or 1 to 1¼ cwt. muriate of potash per acre, applied preferably some weeks before the flax is sown, will increase the yield of fibre, improve the quality, and effectually prevent a diseased appearance known as "yellowing" in the early stages of growth. "Yellowing" is often attributed to frost, but the disease is caused in most instances by the presence of a fungus. The Belgians profusely top-dress their flax-

ground with liquid manure with which have been mixed both rape-cake and nightsoil.

Weeding Flax.—The only attention which the flax crop requires in summer is to keep it free from weeds. These will appear as soon as the crop itself; and when the crop can be identified from them the ground should be weeded. Being in broadcast, and thickly sown, the only practicable way of weeding flax ground is by the hand. As the plant is firm and elastic, the stem is not injured by the weeders treading on it, if they are careful. The weeders should not wear shoes, so as to avoid injuring the flax. The crop should be weeded twice if the land is not clean before the plants are 7 inches high. Close hand-weeding is costly, but the increase of crop will more than repay the outlay.

Careful observation shows that, with the exception of a little corn-cockle, practically none of the weed seeds present as impurities in the sowing seed, as now imported from the Baltic and Rotterdam, germinate and grow with the flax crop. One of the dodders attacks the flax plant, but this is fortunately extremely rare. "The flax-dodder, *Cuscuta europœa*, is a plant," says a writer, "which germinates in the ground, and sends up a slender threadlike stem, which, twisting itself about, soon touches one of the stems of the flax amongst which it is growing. As soon as this takes place, the dodder twists itself round the flax, and throws out from the side next to its victim several small processes, which penetrate the outer coat or cuticle of the flax, and act as suckers, by which *the parasitical dodder appropriates to its own use the sap which has been prepared in the flax, upon which the growth of the flax depends.* The dodder then separates itself from the ground, and relies solely upon the flax for its nourishment, producing long slender leafless stems, which attach themselves to each stem of flax that comes in their way. Thus large masses of crop are matted together, and so much weakened as to become almost useless."[1] A thorough weeding will remove this pest from the soil before it has the power of injuring the flax plant.

[1] *Garden. Chron.*, Feb. 10, 1844, 189.

From the time the weeding is finished the crop needs no further attention till the pulling time approaches, usually in July or early August.

Pulling, Steeping, and Drying Flax.

Pulling.—The flax plant is pulled up by the root. The pulling is done after the plant has flowered and the seed attained a certain degree of maturity in the capsule or boll which contains it. As to the proper time to begin pulling, great care and judgment must be exercised. If pulled too soon the fibre will be weak; if allowed to ripen too much, the fibre will be dry and coarse, and deficient in spinning quality.

Flax is considered to be ready for pulling when all the leaves from the base up to half the height of the plants have fallen from the stalks. A more technical method of determining the fitness for pulling is to cut the ripest seed boll of an average plant transversely with a sharp penknife. The crop is ready when the seeds in the boll have lost all traces of milkiness, are firm and of a brownish colour. To defer pulling until too late a stage is a more usual fault than to pull the crop in too green condition. If allowed to become too ripe, the stems, particularly on light soils and in bright sunny weather, "fire"—*i.e.*, turn brown at the lower end—with disastrous results to the fibre.

Method of Pulling.—The crop is pulled by hand, and it is usual for the workers to pull a flat or ridge each. If the flat is narrow, he will catch the flax and pull with the right and left hands alternately until he has as much as he can hold. The flax is then tied in sheaves, or *beets* as they are called in Ireland. The sheaves are often tied with rush bands and made 15 to 18 inches in circumference, and in dull weather may be set up in stooks for a day or so before being carted to the retting pond. It is most essential to keep the flax *even* at the root-end, and this cannot be done without time and care; but it can be done, and *should always be done.* The *beets* or sheaves should always be equal-sized, straight and even.

Rippling.—In the flax-growing districts of Ulster rippling, or the removal

of the seed bolls, is seldom if ever practised, the flax being steeped as soon as practicable after pulling. Recent experiments prove that rippling green flax is not remunerative, unless the crop is much branched and has produced an abundance of seed.

The process is carried out by pulling the seed heads of handfuls of the flax through an iron comb, a foot or so in length, fixed in an upright position across a plank which is carried on two supports about 18 inches high. The two men engaged in rippling the flax sit astride the plank facing the comb and each other, and strike their handfuls alternately through the comb. The seed bolls fall on to a sheet placed on the ground.

The arrangement of labour should be such that the rippling goes on simultaneously with the pulling. The rippled plants should be tied in sheaves, to be taken to the watering-pool to be steeped.

The Bolls.—The green bolls containing the seed should be thinly spread on the floor of an airy loft, and frequently turned to prevent heating. When thoroughly dry the bolls may be crushed and the linseed separated by a winnower or sieves. Seed obtained by this method is not suited for sowing purposes, as it is not well developed and matured. It can, however, be usefully employed as a food for cattle.

Another Method of Harvesting.—In Yorkshire and in certain districts of Holland and Belgium the crop when pulled is dried on the field. One plan is to stand up the flax in loose small sheaves, with the root end well spread out, so that the air can circulate freely between the stalks. If heating or fermentation takes place in the sheaf, the fibre is at once spoilt. When dry, the flax is taken to a central rettery, and there rippled before being steeped. Seed thus obtained is better developed and more mature than that from green bolls.

Steeping or Retting.—Next comes the steeping, a most important process. The object of steeping the flax plant is to separate the outer fibre of the stem from the inner core to which it is attached by adhesive mucilage. By retting this mucilage is changed, and the process of separation of the fibre is completed in the scutch mill. Wherever possible, a pond with a clay bottom should be selected for the retting.

The question of water for the steeping pond is most important, for the quality of the fibre is largely dependent upon the water used. The most suitable is soft, and waters containing lime or iron compounds should be carefully avoided. Care should be taken to prevent flood water getting into the pond whilst retting is in progress. A very gentle even flow or trickle of water through the flax may, however, be beneficial. The finest of the Continental flax is retted in sheeted crates in the slow-flowing Lys at Courtrai. Good results are often obtained by retting flax in a large volume of water.

The sheaves or beets of flax are placed in rows, root or boll end down, in a somewhat sloping position in the pond, which should be narrow enough to enable the sheaves to be placed in position with a pitchfork from the bank. It is a good practice to allow some water to stand in the pond for a few days before the flax is put in. The sheaves are then weighted with stones or sods and the flax covered with about 3 inches of water. If during fermentation the sheaves rise, more stones are placed on them. The length of time required for the retting operation depends upon the water, its temperature, and the nature of the straw. Suitable water, warm weather, and coarse straw will conduce to quick retting. The average time taken for retting in the north of Ireland with water at 64° Fahr. is about nine days.

To determine when flax is properly retted demands much skill. Of all the operations performed by the farmer in connection with the crop, this is the most technical. The most practical and simplest test to employ is to draw straws from various parts of the retting pond, and to break each stalk at two places about 5 inches apart. Should the core be easily drawn—*i.e.*, should it not adhere to the fibre—the flax is sufficiently retted and may be taken from the pond.

Under-retted flax requires severe scutching to get rid of the woody core, and loss of fibre ensues. If the flax be

over-retted, the fibre is soft and breaks away in the scutch-mill, and a large quantity of tows results.

Drying. — When taken from the retting pond the sheaves may be heaped for a short time, three or four hours, in order to allow the water to drain away. They should not be heaped for long, otherwise they will heat. The flax is then taken to a rather bare grass field, where the sheaves are opened and the flax spread evenly and lightly in rows to dry, being well shaken out in order that the stalks do not adhere to one another. A slight shower will not be deleterious to the flax when spread, but with continued rain retting will proceed, and there is danger of the flax being over-retted.

In unsettled weather the flax may be dried by setting it up in handfuls with the root or butt end on the ground in the form of a hollow cone, the boll ends being slightly twisted together. But in the case of high winds following this practice, the flax is liable to injury by being blown about.

Lifting.—When dry, the flax is carefully gathered, tied as evenly as possible with the rush bands, stooked for a week or so, and then stacked or stored for a little time before being scutched. Care should, however, be taken that the rush bands are properly dried, or otherwise "streaky" flax will result.

In all processes involving the handling of the flax—*i.e.*, pulling, drying, and lifting—the utmost care should be taken to keep the stalks as even as possible and square at the root end.

"The proper culture and preparation of flax require more care, exertion, and expense than the old slovenly method; and those who will not give those requisites would do wisely to abstain from growing flax altogether. Any other crop will abide more negligence. Flax is proverbially either the very best or the very worst crop a farmer can grow." [1]

Scutching.—This is more distinctly a part of the manufacturing process, and therefore does not come within the scope of this work.

Growing and Saving Seed.—The saving of mature seed by drying the flax straw on the field entails much labour, particularly in a rainy season. Furthermore, to ensure the seed being fully mature the flax must be allowed to ripen to a stage beyond that desired for the yields of fibre of highest quality. For these reasons Irish flax-growers do not save the seed of their crop, but are content to import their seed for sowing purposes.

Yield.—In Ulster 4½ cwt. of scutched flax, or 36 to 40 cwt. of dried straw, is regarded as a fair crop, though these quantities are often exceeded. When the crop is grown specially for seed, a yield of 8 to 10 cwt. of linseed per acre may be expected.

Selecting Seed for Sowing.—Good sowing seed should be of bright colour, not too dark, but plump and free from broken, immature, or otherwise imperfect grains and weed seeds. A good sample should conform to the standard above-mentioned as regards purity, germination, and relative weight.

Old Seed.—Seed two years old is sometimes sown, but only when in any season the weather during the seed harvest on the Continent has been particularly bad, and when in consequence a good sample of new seed is extremely difficult to procure, is this plan to be followed; and should a grower propose to use old seed, he should take steps to ascertain the germinating power of a sample, by sowing a little in moist sand placed in a shallow earthenware dish, which may be kept for a few days in a living-room.

Flax-pond Water.—The water left in the pond after retting flax is extremely poisonous to salmon and trout, and should not be allowed into a stream stocked with these fish, unless in time of flood, when the pond water will become well diluted with that of the stream. The smell from retting pond water is very objectionable. Contrary to the opinion sometimes expressed, such water has no manurial properties.

FLAX-GROWING IN GREAT BRITAIN AND IRELAND.

The flax-growing industry has almost died out in Great Britain. A few decades ago the crop was largely grown

[1] Henderson's *Cult. of Flax*, 1.

in certain districts of Yorkshire and Lincolnshire, and also in Scotland. There has been a most serious decline likewise in Ireland, but during the last few years more land has again been devoted to flax in Ulster. The reasons for these changes are: (1) the fall in price of flax fibre consequent upon increased imports from the Continent, particularly from Russia; (2) the relative large amount of manual labour required in the cultivation, harvesting, and after-treatment of the crop, and also, in regard to Ireland, (3) the importation and use of inferior sowing seed.

Former Uses.—For domestic purposes very small patches of flax have been grown in some parts of England and Scotland for a very long time. But except in certain districts it has never taken rank in these countries as an ordinary farm crop. Indeed, even the small patches of flax or lint for domestic use have in most cases become things of the past. The "lint-pools," once dotted pretty freely over Scotland, have nearly all disappeared, and many of the Scottish and English farmers of the present day have never seen a stem of flax growing.

Recent Trials.—Between 1880 and 1887, and again in the early nineties, there was a good deal of discussion as to the propriety of introducing flax as a farm crop in England and Scotland. In several parts of the country the crop has been tried upon small patches, but the results financially have not been sufficiently good to warrant any great extension of the enterprise.

Outlet for Flax Straw.—In the north of Ireland flax-growing is pursued because, in the extensive linen-mills of that industrious province of the Green Isle, there is a sure and ample demand for the fibre. There, indeed, flax is grown for the sole purpose of supplying flax fibre to these linen-mills. The two industries go hand in hand, although the one is not now essential to the success of the other. Little attention is given to the seed in Ulster, for the reason that, by allowing the seed to ripen, the fibre of the flax, the main concern of the Irish flax-grower, would be somewhat injured in quality.

It has been well shown in the various trials conducted that the climate and soil in most parts of Great Britain are well suited for the successful growth of both flax straw and flax seed; but even in the neighbourhood of flax spinning-mills, for instance near Dundee, no flax is grown as a farm crop, and the spinners depend entirely on fibre imported from the continent of Europe.

Uses of Flax Seed.—For flax seed, or linseed as it is more commonly called, there will always be a reliable and satisfactory market. Its high feeding properties are well known, and it is an article which is easy of transport. From linseed is prepared linseed-oil, a valuable article of commerce.

Uses of Flax Straw.—With the flax straw the case is different. It makes admirable thatch, but the demand for this purpose would never be worth reckoning. Its most remunerative use is the manufacture of linen. Unfortunately in England there is no such general demand for it for this purpose as there is in Ulster and Scotland. Whether or not the demand may arise, or could be raised up by any concerted action, is a very doubtful point.

Flax Straw for Paper-making.—Flax straw is also adapted to the manufacture of paper. Its value for this purpose, however, is kept severely in check by the abundance of other commodities which are more suitable, and which—by the processes of manufacture now known—can be manufactured at less outlay. It is just possible that methods of paper-making may yet be discovered which will provide a remunerative outlet for flax straw in that ever-growing industry.

Experiments on the growing of flax straw for paper manufacturers [1] were carried out by Mr Richard Stratton, The Duffryn, Newport, Monmouth, in 1880 and subsequent years, the seed being also saved for marketing for feeding purposes. These experiments showed that the cultivation of the crop for these purposes would be remunerative if for the dried straw a price of £4, 10s. per ton, and for the linseed 16s. per cwt., could be obtained. Consequent, however, on the introduction of new pro-

[1] *Journal Royal Agric. Soc.*, Eng., sec. ser., xviii. 461.

cesses of manufacture and the utilisation of other and cheaper raw materials, the paper manufacturers could not continue to guarantee this price for the straw.

Other Methods of Retting. — Retting in ponds as carried out by flax growers is a putrefactive or rotting process, and is brought about through the agency of bacteria, which are naturally present in pond water. Attempts have therefore been made to use pure cultures of certain putrefactive bacteria obtained from good retting ponds for this purpose. Up to the present, however, these trials have not met with success, for the resulting fibre has been of a harsh nature and wanting in spinning quality. Various systems of so-called artificial retting have been patented. Some such systems comprise retting in tanks of special construction, or containing water of regulated temperature. It is claimed that by these means the conditions are rendered uniform and the retting is more under control. Though a relatively high yield of fibre of good quality, strength, and colour has been obtained in some of these processes, the extra cost incurred in apparatus and labour has rendered them unremunerative. Other systems of artificial retting consist in treating the flax straw, usually in the dried state, with solutions of certain chemicals to dissolve the mucilage which unites the fibre to the woody core of the stems. The fibre obtained by these systems is coarse and weak, and hackles badly in the spinning-mills. None of these processes has yet been found as satisfactory as pond retting, but new processes are constantly being devised.

SUBSIDIARY FARM CROPS.

KOHL-RABI.

Properly speaking, the kohl-rabi (*Brassica oleracea*) is not a root crop. Its bulb is formed by an enlargement of the stem or stalk, and it is thus grown for its stem and not for its root. Nevertheless it falls into the rotation with the root crops, and is cultivated for the same purpose, namely, to provide winter food for farm stock.

Kohl-rabi was cultivated in this country as far back as 1734, but it was not generally known till about 1837. Two varieties are grown in this country, the one purple, the other green, and of sub-varieties some are round and others oblong.

Advantages of Kohl-rabi. — Kohl-rabi undoubtedly possesses high merits as a field crop, and it is surprising that in England especially its cultivation has not extended much more widely than has been the case. In Scotland, and other parts well suited for turnips, there may be little necessity for it, but on the stiff clay and soft fen lands of England, which are well suited for kohl-rabi and badly fitted for turnips, it ought to be grown more largely.

The advantages of kohl-rabi as a field crop are thus forcibly stated by Professor Wrightson:[1]—

"It is subject to no diseases and few insect attacks. Like the turnip, the young plants are liable to the depredations of the turnip flea-beetle, but in a less degree to swedes and turnips. It thrives on two classes of soils upon which turnip cultivation cannot be very successfully carried out—namely, upon the stiffest classes of clays, and the fen-lands of East Anglia. It possesses great powers of resistance to drought, and in fact thrives best in hot and dry seasons. It is exceedingly hardy, and resists frosts successfully. The crop may therefore be left over till the spring of the year. The leaves are of the same quality for feeding purposes as the stems, and resemble rape or kale leaves in nutrient properties. It is well suited for cow-feeding, as it does not impart an unpleasant flavour to milk. It is well adapted for sheep-feeding on the ground, because the bulb

[1] *Fallow and Fodder Crops*, 190.

being supported upon a footstalk it can all be eaten without the waste which is inevitable when turnips are fed. It is an excellent feed for ewes and lambs in the spring, as it supplies leafy herbage as well as more solid food."

Uncertain Crop.—Perhaps the influence which has been most instrumental in restricting the cultivation of kohl-rabi is the belief that it is rather uncertain in its growth—liable to grow to a mass of leaves with insufficient development of bulb. This drawback is being gradually removed by the raising of improved varieties which are more reliable in their development.

Soil for Kohl-rabi.—Kohl-rabi grows well on all soils adapted to swedes, and may also, as we have seen, be cultivated with success on stiff clays and fen lands.

Tillage and Manuring.—These should be very similar to what are best suited for mangels—deep autumn tillage and dunging, grubbing or cultivating in spring, with a liberal dressing of nitrogenous manures.

Planting or Sowing.—Kohl-rabi may be sown either on the flat or in raised drills exactly like turnips; or the plants may be raised in seed-beds, and transplanted into rows 25 to 27 inches apart, with from 10 to 16 inches between the plants. The seed should be sown in the seed-bed fully two months before the time for transplanting, as the plants should be about 8 inches high before being transplanted. From 10 ounces to 1 lb. of seed sown thinly in rows a foot apart, in a well-prepared seed-bed, should produce sufficient plants to cover one acre.

Some particularly careful farmers always raise a few kohl-rabi plants with which to fill up blanks and odd corners in the root field.

Time for Sowing.—The seed may be sown in the drills in March or April. Transplanting may take place from the first of May till the middle of August.

Thinning and Hoeing.—When sown directly in the field the plants are thinned like turnips, with wider intervals between the plants—from 10 to 15 inches. The after tillage and hand-hoeing is exactly the same as for other root crops.

Produce.—From 20 to 25 tons per acre are common crops. Occasionally the produce reaches from 30 to 35 tons or more.

Storing Kohl-rabi.—Kohl-rabi may be stored in the same way as swedes.

CABBAGES.

The growing of cabbages is dealt with under the section on Forage Crops, p. 371 of this vol.

CARROTS.

Carrots (*Daucus carota*, Natural Order *Umbelliferæ*) are more of a garden crop than a crop for general field culture. Yet on most farms with suitable soil a small patch of them may be grown with advantage. Carrots are, in limited quantity, excellent food for horses; and with capital results the carrot-tops may be used as food for cows in milk.

Carrot-tops as Food for Stock.—The high feeding value of carrot-tops is not generally known or acknowledged among farmers, for the tops are, as a rule, left on the ground, just as in the case of turnip-tops. Mr John Speir, Newton Farm, who grows carrots extensively for the Glasgow market, says that carrots form an excellent class of food for any kind of farm stock. They are relished extremely by both sheep and cattle, dairy cows doing particularly well on them. A good few tons of leaves are yielded by each acre of well-grown carrots, and a ton of carrot-leaves appears to be as valuable as the same weight of turnips.

Mr Speir has given carrot leaves to dairy cows for many years, and he prizes them highly for this purpose. He says:—

"I have repeatedly been laughed at for the opinions I held regarding the value of carrot-leaves, by those who had little or no experience of their use, my friends saying they were not worth the cartage, and that I was impoverishing the land by giving them to the cows. I grant I was decreasing the fertility of the land, but I was increasing my milk production, and there was no greater occasion why these carrot-leaves should not first pass through the bodies

of animals before being applied to the land, than should a second crop of hay or clover, diseased potatoes, or, for that matter of it, any palatable farm crop, be it a first or second one.

"**Analysis.**—In support of this view are appended, for the sake of comparison, the analyses of the digestible constituents of a few similar plants, as given by Professor Stewart:—

	Carrot-leaves.	Cabbage.	Turnips.	Potatoes.	Pasture Grass.
Water	82.2	84.7	92.	75.	80.
Albuminoids . . .	2.2	1.8	1.1	2.1	2.5
Carbohydrates . . .	7.0	8.2	6.1	21.8	9.9
Fat	.5	.4	.1	.2	.4

"From this it will be seen that carrot-leaves compare favourably with any of the other articles of food, and although considerable latitude be allowed for variation in the analyses of the samples here given, there is still room enough for much to be said in favour of carrot-leaves. If we allow the stock themselves to be the judges, the point will be easily settled, as the carrot-leaves will be taken in preference to almost any of the other foods named.

"I may here mention in support of this view that it is well known that hares and rabbits travel long distances to feed on carrot-leaves, and they are as dainty in regard to their food as any animals on the farm. In my own case I have for very many years used the produce of from 15 to 20 acres annually with the most satisfactory results, while throughout the country generally it is only the few here and there who do use them anything like extensively. Those farmers who allow them to lie and rot would be considering they were extremely careless if they allowed even a tithe of the same weight of turnips to lie rotting in the fields, while they pay no attention to what is an equally if not more valuable crop, although at the same time a more perishable one."

It is a difficulty of carrot-tops that they cannot be stored like roots. Still, in small heaps they can be kept fresh for a few weeks in the cold season.

Soil for Carrots.—Carrots, having a strong deep root, require soil of considerable depth. A good sandy loam is best adapted for the crop. Excellent crops of carrots are grown on well-manured land with a mossy tendency.

Tillage and Manuring.—The land must be deeply cultivated in the autumn. If the subsoil is stiff, it should be loosened by the subsoiler. Autumn dunging is generally preferred, but where this is not convenient the dunging may be done in spring as for other root crops. Carrots will take as heavy dunging as any of the root crops. The dressing of artificial manure applied may consist of from 3 to 5 cwt. superphosphate, 1 cwt. of potash salts, and 1 to 2 cwt. of nitrate of soda, sown as a top-dressing just after singling, or in two portions, one before and the other after singling.

If the land has been dunged and well tilled in the autumn, little cultivation in spring will suffice. A fine tilth and a loose range for the searching root are very desirable. Yet harm may be done by overworking the land in spring.

Cleaning for Carrots.—It is specially important to have the land for carrots as thoroughly cleaned as possible. Land should only be selected which is in good order and clean, as no amount of cleaning of dirty land just before the crop is sown is likely to turn out satisfactorily. Land inclined to grow chickweed or any other quick-growing weed with fibrous roots should be avoided if possible, for the keeping of such weeds in subjection among a crop of carrots is not only costly, but the disturbance to the growth of the crop is often so great that the crop is rarely a profitable one. The leaves of the carrot are small, compared with those of mangels and turnips, and the growth of weeds is thus encouraged by the large amount of space which remains uncovered.

Sowing Carrots.—Carrots are usually sown about the end of March and beginning of April. They may be sown in rows on the flat, from 15 to 18 inches apart, or in raised drills from 27 to 30 inches in width. In the latter case, two rows of seed are sown on the one drill.

The wide raised drill is preferred by many, because of the greater facility it affords for cultivating and cleaning the land by horse-tillage.

Preparing Carrot Seed.—About 6 to 8 lb. of seed will sow an acre. The hairy covering of the seeds makes their separation rather difficult, and to overcome this difficulty it is a good plan to mix the seed with fine sand, perhaps at the rate of 1½ to 2 bushels of sand per acre. The seed and sand should be thoroughly intermixed by rubbing with the hands; moisten the mixture with water, spread it out on a dry floor, turn daily, sprinkle with water if it become dry, and when it has lain from a week to ten days in this form, it should be sown, just before the seed germinates. When this preparatory process is gone through with proper care, the plants will come up more quickly than if sown without the week or ten days of incubation. This is an important point, because the carrot plants are so tiny in their earliest stages that, when sown on the flat surface, they are liable to be covered and overcome by weeds.

In many cases a little oats, barley, or turnip seed is sown along with the carrot seed for the purpose of indicating the rows, and thus enabling the hoe to be used with freedom before the carrot plants are very clearly visible.

It is unsafe to use old carrot seed. It should be the produce of the previous year's crop.

Thinning Carrots.—The plants should be thinned when the leaves are from 1 to 3 inches high. Intervals of from 4 to 8 inches, according to the variety grown, are left between the plants. When grown on raised drills, with two rows on each drill, the plants are singled so that they alternate rather than sit directly opposite or abreast in the two rows. Horse and hand hoeing should be pursued as with other root crops.

Carrots and Rye.—The late Professor Wilson described a practice followed by some enterprising Continental farmers, in which crops of rye and carrots are grown upon the same land, so as to overlap each other in rather an ingenious way. He said: "In the light-soil districts of Belgium and Holland, where carrots are cultivated to a far greater extent than with us, it is a common practice to grow them mixed with a crop of rye or flax. In the former case the rye is sown early in the autumn, so as to root well before the winter sets in, and thus come early to harvest the following year. In the spring the carrot seed is sown broadcast as late as the growth of the rye will admit of the harrows being used to cover the seed. This germinates and continues its growth until the rye is ready for cutting, which usually takes place about the second or third week in June. It is then mown with a cradled scythe, care being taken not to cut it so close as to injure the top of the root of the young carrot plants, which by this time have acquired a size about the thickness of one's finger. The field is cleared as quickly as possible of the stooks, the harrows are sent over the ground to disturb the surface, and to drag up the roots and stubble that are left, while the remaining weeds are carefully removed by the hand. The liquid-manure cart follows with a supply of rape-cake mixed up with 'purin,' and in a few days the young plants begin to show themselves again, and by the end of the autumn are in a condition to yield a weighty crop of roots, which, when forked up in the usual manner, leaves the land in excellent condition, both chemically and mechanically, for the succeeding crop of corn."

Varieties.—There are many varieties of carrots in use. The best known are Stump-rooted, James's Intermediate, the Altringham long red, white Belgian, large red, and short red.

Produce.—The produce in average seasons should reach from 12 to 20 tons per acre. It is sometimes more, often less.

Storing Carrots.

Liability to Rot.—Of all the root crops of the farm or garden, carrots are the most difficult to preserve. Unless under exceptional circumstances, they are too tender to be allowed to stand out all winter; and in pits (more particularly in wet or mild winters) they are often extremely difficult to keep till May or June. A little mould may be all that is noticed, with an odd soft carrot here and there, and in a couple of weeks after the whole pit may be a mass of pulp. Where,

therefore, carrots are grown, their proper storing is a matter requiring the most careful consideration.

Time of Storing.—Unless in the very earliest districts, carrots are rarely ripe enough to be stored before the last few days of October or the first week in November. In every case the latter is to be preferred to the former.

Pulling.—One person should pull the roots by catching them tightly and close by the bottom of the leaves, laying them out in rows flat along the top of the drill in which they grew; while another should be intrusted with the selecting and cutting off the leaves. Each pair of pullers should be provided with a potato-graip, with which to dig out any roots the leaves of which may happen to break. Between each pair of those cutting off the leaves, one basket should be provided for holding all split, forked, or otherwise deformed roots; while one or two baskets should be provided for each cutter, into which to put the selected roots. A cart generally goes behind, and each basket when full is emptied into it, the extra baskets being filled while the cart is away.

Carrot-leaves.—The leaves should be kept clean and thrown into heaps behind the baskets, in readiness to be carted to the cattle and sheep at the farm. All classes of cattle are exceptionally fond of these leaves, and thrive well upon them.

Growing and Heating in Pits.—It is of the utmost importance that the leaves of carrots be cut off as near to the crown as possible. If such is not done, the roots grow much quicker in the pits, heat is thereby generated, and the whole in a very short time becomes a mass of putrefaction.

Carrot-pits.—The pit in which carrots are stored should never be so large as potato-pits, from 2 feet to 2½ feet wide being quite large enough. The sides should be as steep as possible, so as to keep them thoroughly dry, and at first they should not be very heavily covered. In other respects the pitting is much the same as has been recommended for potatoes. Carrots, however, require more ventilation, and must on no account be pitted wet.

In a winter in which there is very little frost, a carrot will keep quite sound and fresh lying on the surface of the ground exposed to wind and rain; but shut it up in an unventilated and warm pit, and it will become soft in a week. As a protection against frost, there is not the same necessity to thatch carrot-pits as potato-pits; but as a protection against rain, thatch is about as needful for the one as for the other.

Hares and rabbits are especially fond of carrots, and will do much damage to the crop if they are not shut out by wire netting.

Carrot Pests.—Insect pests which prey upon carrots are dealt with in the sections on Fungus and Insect Plagues in this vol.

PARSNIPS.

The parsnip is the *Pastinaca sativa* of the same Natural Order as the carrot, *Umbelliferæ*. Indeed the two plants are so very similar in their habits of growth that the remarks as to soil, tillage, and manuring for carrots may be held as applying also to parsnips.

Parsnips go still deeper into the soil than carrots, and grow to their best in a heavier loam than that which carrots specially delight in. In the south the parsnip seed—6 or 8 lb. per acre, with a little oat, barley, or turnip seed, as with carrots—may be sown as early as February.

Parsnips are usually grown in rows on the flat surface about 14 or 15 inches wide, and the plants are thinned to from 6 to 8 inches apart.

Among the varieties of parsnips most largely grown are the long-rooted parsnip, the Student, the long Jersey (or hollow crowned), large Guernsey, and Cattle parsnips.

Both parsnips and carrots are found growing wild as weeds in this country. No doubt the cultivated varieties have been raised from these.

The parsnip is possessed of very high fattening properties.

Parsnips may be treated similarly to carrots in regard to tillage and manuring

Storing Parsnips.—Parsnips may be stored in precisely the same manner as carrots. They are not much affected by

frost, and will keep fresh in the store till April. Care, however, should be taken that none of the leaves remain attached to the roots.

Parsnip-Leaves as Food for Cows.—The leaves of parsnips make good food for cows. As they begin to decay they should be cut off and given to the cows. In October the leaves come in as a convenient auxiliary to grass; and, if given *moderately*, a good armful per day to each cow will impart almost as much richness to the milk as the parsnip itself.

MARKET-GARDENING.

The decline in the prices of ordinary farm products has induced farmers, in many parts of the country, who formerly devoted their land and means almost entirely to the production of grain and beef or mutton, to give a share of their attention to the growing of vegetables, fruit, and in some cases flowers, for the use of the dwellers in towns, who have no facilities for the growth of such, but are able and willing to pay good prices for them. The area under these crops is on the increase in this country, and under judicious management there is room for further extension.

Vegetable culture, as a rule, is extensively carried on only in the vicinity of some populous centre, where large quantities of town dung can be procured. Fruit is easier of transit than vegetables, and may be cultivated anywhere, where the soil, climate, railway facilities, and supply of manure are suitable; while the same may be said of flowers.

Dairying and Market-gardening.—Often the growth of vegetables, fruit, and flowers is combined in one establishment, and to this system of farming a profitable adjunct is a dairy. The cows composing the dairy can get almost all the year round a supply of green stuff very suitable as food, which would scarcely pay for its cartage to a more distant dairy, and which is too valuable for manure, and as such is often difficult to plough under.

For this purpose imperfectly grown kale, cabbages, cauliflower, broccoli, and Brussels sprouts are available almost through the entire year. Then carrots and parsnips, unfit for table use, make good food for cows, and their leaves, which are very bulky where a heavy crop is grown, are much relished by cows, and weight for weight appear to be as valuable as turnips. In the culture of turnips for table use, as well as of such other plants as beet, peas, and beans, there is also always a considerable quantity of what would otherwise be waste food, which can be turned to good account through the medium of milch-cows. Then in the growth of such crops there are plots of land which are bare at a season of the year when it is unsuitable to put these under any of the regular crops, and which may be profitably utilised in growing tares for the cows. Tares, with the winter and spring varieties, form a very accommodating and valuable crop for such circumstances. They do not necessarily occupy the ground for any great length of time, and they generally do well on heavily manured land.

For these and many other reasons the growth of market-garden crops should, wherever practicable, be combined with dairying. And unless there are circumstances of an exceptional character, the class of dairying most suitable will be the production of milk, and the sale of it fresh from the cow.

This system of combined dairying and market-gardening has been pursued extensively and with success by Mr John Speir, Newton Farm, Glasgow, and to him we are indebted for the following notes on the culture of subsidiary farm crops.

Savoys.

The culture of the savoy is much the same as of the cabbage, and equally as easy. Plantations are usually made at intervals from spring to midsummer, the latter plantings generally following some early cleared spring or winter crop.

Around Dublin they are grown to an enormous extent. The Dublin population are probably the heaviest cabbage-eating people in Britain; while large quantities are also annually exported to Glasgow, Liverpool, Manchester, and Bristol.

The farmers around Dublin grow first a crop of early potatoes, which is cleared

off in June and July. The land is then immediately planted with savoys, which form good heads by the New Year, thus allowing the land to be cleared in time for any spring-planted crop.

Greens, Cauliflowers, &c.

Instead of savoys, greens or kale may be planted after an early potato crop is cleared off. This custom is followed very largely around Belfast, and on some of the earliest farms along the Ayrshire coast, from Girvan northwards. Greens are always in fair demand, and often give a good return per acre.

Brussels sprouts, cauliflower, and broccoli resemble the savoy very much in culture; and in manure they all have much the same requirements. General dressings are 10 to 12 tons town dung, 4 to 6 cwt. of superphosphate, 2 to 4 cwt. of nitrate of soda, and perhaps 4 cwt. kainit per acre.

Carrots, Parsnips, Beetroot, and Onions.

Though nowadays grown on farms to a moderate extent, these are standard crops in market-gardens. Their culture is very similar on the field and in the garden. Carrots succeed best on sandy or mossy soil; parsnips on loam or clay; and beetroot on any free soil, which, however, must be in the very highest state of cultivation and fertility. Beetroot requires a good climate.

Onions also thrive best on good open soil well manured and kept free from weeds.

A portion of the crop is often sown in early autumn. This is cleared off before the spring-sown onions are ready to pull, while they in their turn are removed by the beginning of September to make room for cabbages to stand the winter.

Leeks.

Leeks are constantly in demand from September till April, when new autumn-sown onions again come in. There is thus a sale for the one or the other throughout the whole year.

Leeks, owing to their excessive demand for manure, are not so easily grown as a field crop as onions. There is, however, no great difficulty in cultivating them successfully where the land is clean and in moderate condition.

Manuring.—Probably no crop can stand so much forcing with nitrogenous manures as leeks, so that, whenever they are not growing to one's mind, a thorough weeding and heavy dressing of any soluble nitrogenous manure will be sure to bring them away rapidly.

Culture.—Leeks are generally sown in beds or frames, from which they are afterwards transplanted in the field in rows about a foot wide, with about four inches between each plant in the row. In dibbling in the young plants, they are put as deep in as the size of the plant will permit, so that when full grown they shall have as much of the stalk blanched as possible. It is also found that the plants grow much better when only a minute quantity of earth is put into the dibble hole after the plant has been dropped in. When the plants are grown so shallow as to whiten only an inch or two of the stem, they are generally earthed up, to increase as much as possible the length of white stem.

Turnips for Table Use.

Turnips for table use are also a very suitable crop for growing either in market-gardens or on farms near large towns. Their culture is in no way different from the ordinary field culture of turnips, except that two rows are generally sown along one drill. This is necessitated by the smallness of the bulbs and the tops, which, if sown on one drill only, would return a very small crop per acre. Moreover, with only one row of these small roots, a considerable portion of the land would be left bare, and would be immediately monopolised by the weeds. Such turnips are usually taken to market with their tops on, a dozen or fourteen being tied in a bundle by passing a straw or other rope round the tops.

Turnip-tops.—Farmers in the counties around London and some other large towns derive a substantial return by selling turnip-tops, particularly the young sprouts in spring, for use as "greens" in soups and with meat.

Beans and Peas.

Beans and peas can also be profitably grown where there is a market for them in a green state. In most large towns

they are bought up in considerable quantities. Both are pulled green and sent to market in hampers or sacks, and sold at so much per stone or cwt. The return per acre is not generally very high, but the crop does not require much manure, and the ground is early cleared for something else.

Beans do best on moderately firm clayland thoroughly drained, while peas are more suitable for free-working lands. When grown on a large scale for green pulling for market, peas are seldom staked. The drills are made from 3 to 4 feet apart, and the haulm is allowed to grow along the ground, but not to catch the next row.

Rhubarb.

There are few crops of the market-garden class so easily grown by the ordinary farmer as that of rhubarb. The cost of the roots is considerable, ranging according to size, variety, and date of sale from £20 to £80 per acre. The roots are usually planted in rows 3 feet or less apart, and about 30 to 33 inches between the plants. One, two, or occasionally three pullings may be taken each year. Summer rhubarb does not, however, sell high, from 20s. to 30s. per ton being a common price, with 40s. early and late in the year.

Glasgow is the principal centre of the growth of rhubarb in Scotland, and Leeds in England. Around the former city many farmers have from 20 to 30 acres under rhubarb. Most of these have forcing-houses, in which it is grown during winter, several of them being able to force the roots on from 5 to 10 acres in a single winter. Roots which are intended to be forced in winter have few of the leaves taken off during the preceding summer. After forcing the roots are of little value. If again planted they yield no crop the first year, but give a moderate crop the second one. They are, however, not ready to force again until four or five years old.

Rhubarb can make profitable use of liberal manuring. Moderate dressings of dung and liberal additions of artificial manures usually give the best results, common allowances of the latter being from 4 to 5 cwt. superphosphate, 2 to 3 cwt. nitrate of soda, and about 4 cwt. kainit per acre.

In all cases where lime is supposed to be deficient, basic slag should be substituted for superphosphate.

Strawberries.

Strawberries are the fruit easiest brought to a bearing condition and requiring least skill for their culture. They therefore form the fruit most suitable for the ordinary farmer to begin with. In the valley of the Clyde, between Lanark and Hamilton, the growing of this fruit has been largely pursued by the farmers. The farms there are all more or less devoted to dairying, yet for a distance of six or seven miles along both banks of the river every one has made a trial of strawberries.

Irregular Produce.—A year occurs every now and again when they give a comparatively poor return; but on the other hand there are years when an enormous production is obtained.

To such an extent has their culture been carried in this locality, that as many as fifteen railway waggon-loads of strawberries have been known to leave a single station in one day, and yet there are three stations which are all more or less fed from this district.

Near Crieff, Dumbarton, and Aberdeen, in Scotland, and in different parts of England, strawberry culture has likewise made rapid progress in recent years.

Planting.—The plants are generally dibbled in beds in spring,—three rows, about 15 inches apart, being allowed to each bed.

The Fruit.—The finest of the fruit is sent to market each morning for dessert purposes, the remainder being pulled during the day for making preserves.

Price.—The preserve-makers generally arrange at the opening of the season for so many tons from each grower, the ordinary price of recent years being from £16 to £28 per ton. Few have ever been sold at less than £12 per ton, and occasionally the price exceeds £30 per ton.

Duration of Plants.—The plants yield no fruit worth speaking of the first year, and are at their best the second and third years, after which they deteriorate quickly. Most growers do not crop

them more than four years, after which the plantations are ploughed down, and a grain or green crop taken.

The best plants for making a new plantation are yielded by those which have been put down the year previous.

Labour and Soil.—To enable the cultivation of strawberries to be successfully carried on, a plentiful and cheap supply of labour must be at hand. The soil should lean to the heavy side rather than the light. They rarely do well on very light soil.

Bush Fruit.

The cultivation of bush fruit, be it black, red, or white currants, or gooseberries, is not so easy of attainment as that of strawberries, and is not so well suited for a farmer holding land under a short lease.

Cost of Planting.—The purchase of the young bushes is a rather costly business, and instead of only one year being lost before fruit-bearing begins, as with strawberries, two, three, or even four may be said to elapse before a very large return is obtained, even where the climate is good and the bushes fairly well grown when put in.

Catch Cropping.—As the rows of bushes are, however, generally from 5 to 6 feet apart, a good deal can be made out of the spaces between the rows by growing vegetables. In these spaces turnips, cabbages, cauliflowers, beet, parsley, leeks, and onions may advantageously be grown; and if the culture of flowers is attempted, these spaces form very suitable places for the growth of wallflowers, narcissi, snowdrops, and annuals generally.

Disease in Black Currants.—Black currants, when they do yield well, usually bring a large money return to the fortunate grower—not because they bear a heavier crop than other fruit, but because of their extreme liability to disease. To such an extent has this pest prevailed in the fruit-growing districts all over the country, that the larger plantations are being rapidly grubbed up. The disease, which is dealt with in another part of this vol., seldom attacks the red or the white currant.

Gooseberries.—Gooseberries are occasionally seriously attacked by the caterpillar, but it does not carry with it any of the destructive effects of the black-currant mite. In recent years gooseberries have not been bringing anything like the same price in the market as formerly, and in consequence growers are rather chary of making new plantations. For good gooseberries from £8 to £12 per ton are common prices. The attacks of the fungus and insect enemies of gooseberries are noticed in other parts of this vol.

Manuring for fruit may be similar to that for most vegetables, with, in all cases, a liberal allowance of a potash manure.

Raspberries.

Raspberries are now largely planted in many districts, particularly in the neighbourhood of Blairgowrie, in Scotland, where they have succeeded very well. They are usually planted in rows about 5 feet apart. One or, it may be, two wires are stretched along the rows on posts, and to the wires the canes are tied. This prevents them rubbing against each other when knocked about by the wind, and admits of the fruit being more easily gathered.

Orchards.

In many parts of England, especially in the southern counties, the cultivation of tree-fruit, such as pears, apples, plums, and damsons, is carried on to a large extent and with good results.

It is only on a very limited area of Scotland that the cultivation of large or tree fruit for the purpose of sale has been attempted. The largest breadth in one lot probably centres round the village of Crossford, on the Clyde below Lanark. Both sides of the river there are for several miles devoted to the cultivation of fruit-trees, which has been carried on for a very long time. During the days of the old stage-coaches, it was a comomon remark that a handful of plums could always be gathered in the season from the trees on the roadside, while the coach passed underneath them. There is still a considerable extent in plums; but apples hold the largest share, pears being grown to a less extent.

New orchards are being continually

planted and old ones uprooted, the new ones being, as a rule, planted with small fruit in the intervening spaces. Owing to the shelter which the deep and narrow valley affords, this locality is extremely well suited for fruit, and all the farmers in the valley have more or less of their land under it. Considerable orchards at one time existed in the Carses of Stirling and Gowrie, but lately these have not been well attended to, and are fast disappearing. Fruit importations have considerably checked home planting all over Britain, and it is very questionable if there are many districts in Scotland where it can be carried out with much prospect of profit.

In the British Isles tree-fruit has never received such careful cultivation as is given to it in the United States and Canada. There the best orchards are regularly cultivated the whole year over, and the growth of the trees so treated is almost double what it is where the land is sown with grass or is left uncultivated. The usual method in Canada is to either summer fallow the land between the trees or to do so up to the end of June, and then sow a cover crop such as buckwheat or clover, which is ploughed under in autumn.

FLOWERS.

The demand for pot-plants for house decoration, and cut flowers for the house, personal decoration, marriages, and funerals, has so much increased among the dwellers in towns, that there is ample room for the growth of these by those farmers who have a taste for flowers, are conversant with their growth, and suitably situated in regard to climate, soil, and disposal.

In sheltered and early situations, wallflowers may be grown by the acre, and if early or late enough, are sure to give a fairly good return. In the middle of the season it may often be difficult to sell the wallflowers even at the cost of carriage; but at the beginning and end of the season they generally do well. The same may be said regarding mignonette, forget-me-nots, and many other flowers of a similar class, which are likely to be grown by the farmer attempting flower-cultivation as an adjunct to his farm.

Bulbs. — Amongst bulbous plants which may be grown for cut blooms may be mentioned the whole narcissi family as plants which are easy of growth, and the blooms of which sell well. The great drawback to the culture of such on a more extended scale than most persons have yet attempted, used to be the enormous cost of planting even one acre with these bulbs. They are, however, much less costly now than they used to be, so that there is more inducement for beginners to invest in them. Two farmers in the south-west of Scotland grow something like 10 acres each of these bulbs alone, and are generally presumed to be doing well.

For sale as plants, the farmer might also grow wallflowers, daisies, pinks, primroses, and other flowering-plants, a limited quantity of which can profitably be sold in most large towns.

Indoor plants cannot be grown without the aid of glass, and therefore need not be noticed here.

RED-CLOVER SEED.

The growing of the seed of red-clover (*Trifolium pratense*) is pursued to some extent in various parts of England.

Where grown for its seed, red-clover is sown alone. Were it to stand for seed at the first cutting, when the blossoms do not appear simultaneously, the seed of one plant would be matured, while that of another would be scarcely formed. At the second cutting the flowers blossom at one time, and the plants attain the same height, the crop appearing one of the richest description in our fields. The first cutting in ordinary practice is delayed until the plant is in full bloom, and sometimes till the bloom has begun to decay; so no surprise need be felt when a full second cutting is not obtained after such treatment.

From some of the imported seed it is impossible to get a good second cutting; but if the seed is obtained from a reputable British firm of seed-growers, there should be little difficulty about this, whether the seed is of home or foreign growth.

To secure a good second cutting, the first crop should be cut before the plant comes into bloom; or sheep might eat down the crop by the end of May or beginning of June, when the second growth will come away thick and vigorously.

The red clover is injured by insects when in bloom.

Cutting and Drying. — When the blooms of the plants become withered, the crop should be cut by reaper or scythe in August or September. If put together in heaps, a slight degree of heating will cause the seed to leave the husk more readily on being threshed; and on the heated heaps being spread out to the sun, the crop will soon be dry enough to lead home to the steading, to be threshed with the flail or threshing-machine.

When the weather is good this plan may be adopted, but should it prove damp the crop should be sheafed, and set into stooks to dry, and afterwards carried to the stackyard and built into stacks, to be threshed at a convenient time. There is little danger of the seed falling from its husk, as it is difficult to thresh out; but the heating recommended renders the husk brittle, and easily broken by threshing.

Threshing.—In most districts where red-clover seed is grown, special machines are taken from farm to farm to do the threshing. In other cases the threshing is done by the ordinary threshing-machine or by the flail.

HEMP CULTURE.

Hemp (*Cannabis sativa*, Natural Order *Urticaceæ*) is grown to a very limited extent in this country, chiefly in the counties of Lincoln and Dorest. The climate of Scotland does not suit it. It grows best in deep, rich, moist, alluvial soil. Its mode of culture is in several respects similar to that of flax. Hemp responds well to a heavy dose of dung, the finest fibre being grown after a dressing of about 20 tons of dung, applied in the autumn before sowing.

Hemp is sown towards the end of April, in rows about 18 inches apart, with 3 to 5 pecks of good seed per acre. The plants are thinned out in the rows to nearly a foot apart. The plants throw up a rapid and bulky growth, so that little weeding early in the season is sufficient to keep the land clean. The crop is pulled, stacked, and steeped similarly to flax. The object of the steeping in water is, of course, to rot away the woody part of the stem and separate the fibre.

When the crop is growing, the ground should be watched after sowing until the plants are in leaf, to keep off birds of the finch tribe, which are very fond of hemp seed. Even the young plants are injured by them, — the capsules of the seed, being brought above ground by the embryo, are greedily devoured by those birds. Care should be taken in weeding not to break the young plants, as, if broken, they will never rise again.

A good crop of hemp yields about 16 bushels of seed, and from 6 to 8 cwt. of fibre per acre.

The hemp plant has the male and female flowers on different plants. The male plants are recognisable by the difference of their inflorescence, and in thinning, a number of them must be left in order to the formation of the seed. The male plants ripen long before the female plants, and should be pulled first, so as to promote the formation of a good crop of seed.

The stem of hemp is upright, from 5 to 8 feet high, and is strong and branching. Its valuable fibre makes the cordage of our ships.

An oil is expressed from the seed of hemp, which is used in various industries. The proportion of oil from the seed varies from 14 to 25 per cent. The seed is used for feeding cage-birds.

LAVENDER.

Lavender (*Lavandula*, a genus of *Labiatæ*) has for many years been grown to a small extent in England, chiefly in the counties of Surrey and Herts. It is grown mainly for the distillation of its essential oil, and, according to whether the season is dry and bright or dull and wet, the yield of oil varies from 12 to 30 lb. per acre. The plant does best on sandy loam lying on a calcareous subsoil, with a sunny exposure, not liable to

fog or early frost. The plants are propagated by slips or by dividing the roots. The flowers are collected in August and at once taken to be distilled. The finest oil is got from the flowers. The growing of lavender is not extending to any great extent.

WOAD FARMING.

Though an old industry, woad farming has never been pursued except to a very limited extent in this country. It is now mainly confined to a few centres in the Fen district of England.

The woad plant is used as a colour for fixing the dye, which it seems to have the property of making perfectly fast. Natural dyes are now so easily procured that woad is not much used except when stipulated for, as it is by Government for cloth for the police force, whose blue uniforms rarely lose colour, thanks to the influence of woad.

The woad plant yields three crops annually, and grows from 6 to 7 inches high, when it is plucked in a green state.

EXCISE RESTRICTIONS ON CROPPING.

Seeing that for all our staple agricultural products, corn, hay, potatoes, &c., our markets are free to the produce of the whole world, it may seem rather hard that our farmers should not be at liberty to grow any crop whatever which might yield them good returns.

Tobacco is the only crop the growth of which has hitherto been absolutely forbidden in this country, but for all practical purposes chicory might be classed with tobacco; while the cultivation of flowers and aromatic herbs, for the manufacture of perfumery, is also hampered by excise restrictions. If the sugar-beet industry could be established in the United Kingdom, it would also be chargeable with an excise duty.

Sugar-beet.

Experiments on a fairly commercial scale (¼ acre and over) carried on in Britain clearly proved that not only can a heavier crop of beet be grown in Britain than on the Continent, but also beet equally as rich in saccharine material. Therefore if the possibility of bounty-fed sugar entering British ports were completely done away with, it is possible that sugar factories would be erected here, and would succeed in producing sugar as cheaply as anywhere else. Farmers are much in need of a new crop, particularly such a one as the sugar-beet, which not only produces a large quantity of sugar without taking much fertility from the land, but at the same time leaves a substantial amount of residue which is very useful for feeding milk cows or fattening cattle.

Root-alcohol for Industrial Purposes.

It is no doubt the case that several of our staple crops offer large possibilities for industrial uses, if they could be dealt with without hampering excise restrictions. In particular, the production of industrial alcohol for motor-fuel and other purposes might well engage the attention of our farmers. It promises to become one of the largest industries of the day, and in the production of root-alcohol, from potatoes, turnips, sugar-beet, and other green crops, British farmers could compete, on advantageous terms, in home markets, against petroleum or any other kind of imported motor-fuel. There would have to be denaturation, of course, but if the revenue charges were limited to that and the bare cost of supervision, the charge would not hinder the growth of the industry.

Tobacco.

Whether tobacco could be made a paying crop in this country is doubtful. Tobacco is one of the few articles on which we levy import duty, and the £10,000,000 or so which foreign-grown tobacco annually contributes to our customs receipts is a very strong argument in other than farming circles for not taking the duty off the home-grown article, especially if, as has been officially stated, a £50 per acre tax on home-grown tobacco would only produce half the present revenue from the imported article.

No doubt our farmers could easily grow all the tobacco needed for home

consumption. Experiments in different parts of Ireland as well as of Great Britain have shown that the production of tobacco in quantity in this country would be an easy matter; but in this moist and comparatively sunless climate the fine-flavoured weed, which is the natural product of tropical and semi-tropical regions, cannot be equalled. It is doubtful, therefore, if much will come out of the facilities the Government is now offering for trials with tobacco culture in Great Britain.

Aromatic Herbs.

There is no duty chargeable on distilled waters made from home-grown herbs, but a 10s. licence is necessary to authorise the keeping of a still for this purpose. It is right and needful that there should be some safeguard in this direction, but this tax brings in nothing really to the national exchequer, and only serves to deter small cultivators who might find it profitable to make the growth of flowers and aromatic herbs an addition to other branches of small farming.

Chicory.

Likewise, although there is no official interference with the *growth* of chicory, there practically is, since the only value of chicory is as a commercial crop, and a *drying* of the root is subject to excise regulations and a duty of 12s. 1d. per cwt. of the dried chicory delivered for consumption. A drier of chicory is required to make entry, with the proper officer of excise, of his premises, kilns, and utensils, and to provide to the satisfaction of the Commissioners of Inland Revenue (1) a warehouse for depositing chicory when dried, (2) proper accommodation on the premises for the officers, and (3) scales and weights and assistance to the officers in taking the necessary accounts therewith. The grower is also required to give notice to the officer of the times respectively when he will begin to dry chicory and remove it from the kiln to the warehouse. Dry chicory to be forthwith secured in the approved warehouse, and it may only be removed therefrom in the day-time, on a four hours' notice. Apart from the 12s. 1d. per cwt. duty on dried chicory, these unnecessarily vexatious and expensive regulations do not encourage farmers to grow chicory, even when it might be done with considerable profit to themselves.

ELECTRICITY IN AGRICULTURE.

Before leaving the subject of crops we may refer to attempts which have been made to stimulate the production of the soil by the influence of electricity. At one of the meetings of the British Association at Dublin in September 1908, Sir Oliver Lodge read a paper on this subject, giving the results of experiments conducted in the south of England. He stated that in these experiments it had been found that a discharge of positive electricity into the air above growing plants stimulated and increased their growth. The effect of the electricity was greatest when the sunshine was not very strong and the soil not too dry. In strong sunshine and very dry soil the electricity seemed to over-stimulate the plants. The trials took place on various farms, and all over grain crops gave a substantial increase in yield from the application of electricity.

The results of these trials are quite in keeping with results obtained in similar but cruder experiments conducted many years ago in this and other countries, and it is probable that ere long electricity may come to be recognised as an important factor in the growing of field and garden crops.

THE FUNGUS DISEASES OF PLANTS.

It is unfortunately the case that farmers have nowadays a greater number of fungus, insect, and other plagues to contend against than in bygone times. In a work such as this, therefore, it is important that information should be provided which is fitted to assist farmers in the combating of these plagues. For much of this information the Editor is indebted to Dr R. S. Macdougall.

Fungi belong to that lowest group of plants known as the Thallophytes, or the plants which in their vegetative parts show no distinction into root, stem, and leaf. The plant in the case of a fungus consists typically of a series of much-branched threads known as the mycelium.

These mycelial threads, which may be septate or non-septate, have walls enclosing protoplasm. In feeding, absorption may take place over the whole surface of the mycelium, or special absorbing processes may be developed known as suckers. The fructification of a fungus may be a large structure, and may not appear thread-like, but the seemingly solid fructification is made up of a mass of interwoven threads: thus in the field-mushroom the real plant is in the soil, and consists of numerous threads, while the familiar stalk and cup make up the fruit of the plant.

An extremely important fact to note in connection with Fungi is that none of them possess chlorophyll — the green colouring matter characteristic of most plants, and the possession of which makes green plants, speaking generally, independent. Plants that lack chlorophyll are not able to do for themselves, and Fungi, therefore, have to obtain the carbonaceous food-material, which they cannot manufacture for themselves, either by stealing it from a live host or by living on decaying organic matter. The latter class of Fungi is known as the Saprophytes, of which the mushroom and many moulds are good examples. The Fungi which live off live hosts are known as Parasitic Fungi. The parasite may live on an animal, as in the cases of ringworm and the Fungi which infest salmon and kill flies and locusts; or the Fungus may be parasitic on a plant, and it is with such Fungi that we have to deal here.

Multiplication of Fungi may take place either asexually or sexually. In asexual multiplication pieces of the mycelium broken away and placed in suitable conditions feed, grow, and develop into new plants—*e.g.*, in cultivating mushrooms from the so-called "spawn"; or in asexual multiplication special cells may be produced known as conidia or spores, and any one of these in suitable conditions can alone and without fusing with another develop and give rise to a new mycelium. In sexual multiplication we have special parts produced—male and female—a fusion of male and female elements takes places, and a new individual is the result.

There are interesting examples of Fungi living in helpful partnership with the higher plants. For example, many woodland plants in soil rich in humus are indebted for supplies of carbonaceous and nitrogenous food-material to Fungi which can make use of the carbon and nitrogen in the humus.

THE PHYCOMYCETES.

The Phycomycetes is a family of fungi characterised by a branching mycelium without partitions or septa. Sexual and asexual multiplication are met with.

The "Damping off" of Seedlings (Pythium de Baryanum).

When seedlings—*e.g.*, of cress, or mustard, or clover—are overcrowded and kept in very moist conditions, they fall over, the weak place showing just above the surface of the soil, become pale, then brown, and ultimately rot. This is the result of the attack of the fungus Pythium, the much-branched mycelium of which invades the tissues of the host plant, passing between the cells or eating its way into the cells. The mycelium of this fungus passes from one seedling to another till at last the seed-bed may

be ruined. Pythium multiplies both asexually and sexually. In the asexual multiplication, the ends of some of the mycelial threads swell and get cut off by partitions. These cut-off pieces behave in either of two ways. In drier conditions the round or oval cut-off piece, known as a conidium, gives rise directly to a delicate thread which enters a new host plant and results in a new mycelium. In the presence of water the behaviour is different: the protoplasm of the cut-off pieces divides up into zoospores, which escaping, move through the water by means of cilia—two delicate cilia for each zoospore; these zoospores come to rest, and each gives out a delicate thread or germ tube, which piercing a host plant results in a new mycelium.

In the sexual multiplication of this fungus, the male reproductive organ is known as an antheridium, which is a cell cut off by a partition from one of the threads of the mycelium: a portion of the contents of this antheridium forms the male gamete. The female sexual organ is known as the oogonium: it is a rounded swelling of one of the hyphæ or threads, and a portion of its protoplasm forms the egg-cell. The antheridium comes in contact with the oogonium, a fertilisation process pierces the oogonium wall and the male gamete is carried to the egg. The fertilised egg becomes surrounded by a thick coat and is known as the oospore. The oospore is a resting-spore which may remain dormant in the soil until new seedlings are being grown, when the oospore germinates directly, or gives rise to zoospores, and the new seedlings are infected. An important feature in the life of this Pythium is that though a parasite it is capable of living for a time as a saprophyte.

Treatment.—1. Do not overcrowd. 2. The seed-bed should not be too moist. 3. There must be a supply of fresh air, and access for fresh air and for sunlight. 4. The burning of infected plants with the soil surrounding them. 5. The burying of the oospores by deep ploughing. 6. The fact that the oospores may remain dormant for a time, and that the fungus can live for a time as a saprophyte, should prevent a seed-bed which has been affected from being immediately used again for the same purpose.

Potato Disease (Phytophthora infestans, D.B.)

This fungus first shows itself in Britain towards the end of July and on into August. It is first seen on the leaves, the yellow spots or patches soon turning brown and black. The fungus generally appears during close weather, with a humid atmosphere, especially when mists hang over the fields in the evenings and mornings, and the days are hot and damp. These are conditions well known to favour fungus growth. In dry weather the diseased patches on the leaf do not increase much, but in the humid conditions described, the diseased patches spread over the leaves very quickly, and the above-ground parts of the plant shrivel and rot with an attendant foul odour. Examination of the under surface of a diseased leaf would show round each affected patch a mealy- or floury-looking rim, this consisting of mycelial branches and conidia. The disease may pass from leaf to shaw, and may also infect the tubers either by the mycelium travelling down the stem, or by spores or conidia tumbling away on to the soil and getting washed down to the tubers, where, after infection, brown, dead, sunken patches show on the surface.

Description and Life-history.—The following is part of the description given by Worthington G. Smith in *Diseases of Field and Garden Crops* (Macmillan). This book is no longer completely up to date, but it contains useful figures:—

"For an exact examination of *Phytophthora infestans*, a very minute and extremely thin and transparent slice must be cut from a diseased leaf at a spot where the white bloom caused by the presence of the fungus is visible underneath. A good plan is to cut a diseased leaf in two through a disease spot, and then with a sharp lancet cut an extremely thin slice off from one of the exposed cut surfaces. If the slice last cut is somewhat longitudinally wedge-shaped, it will often best show the structure of the leaf and the contained fungus at the thinner end of the section. The atom to be examined should be placed on a glass slide in a drop of glycerine (this is preferable to water, as the latter often

dries too quickly), and then covered with a clean thin cover-glass.

"The magnification given by an ordinary lens is useless for the observation of the minute fungus now before us, so we must at once place it under the higher powers of the microscope. If the slicing through a disease spot is successful, we shall probably see the atom when magnified 100 diameters (as at fig. 621). The thickness of the lamina of the leaf is shown at A, B; the under side of the leaf is represented at A, from which surface the fungus almost invariably springs. The true upper surface is shown at B.

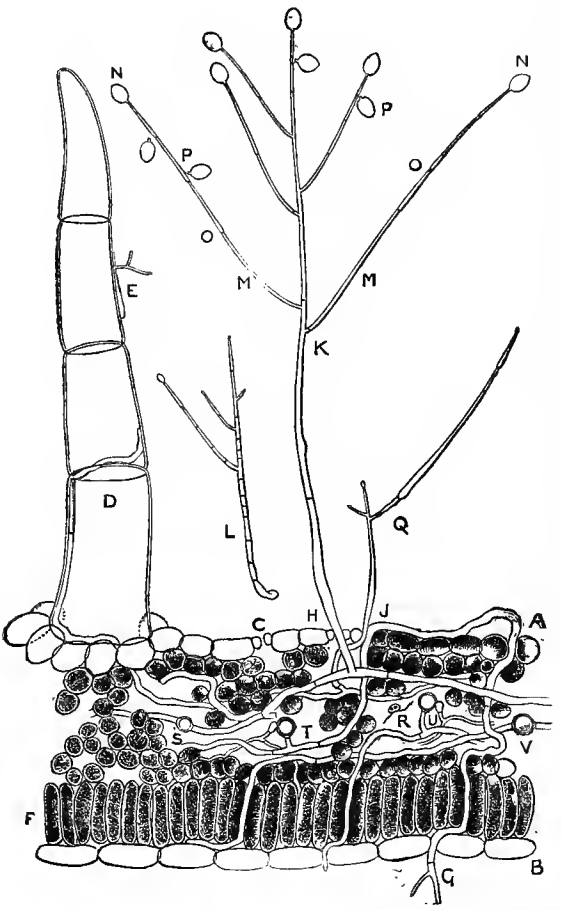


Fig. 621.—*Section through a fragment of a potato-leaf, with the potato fungus,* Phytophthora infestans, *growing within its substance, and emerging through the epidermis. Enlarged* 100 *diameters.*

If we confine our attention for the present to the section of the leaf, we shall note that it is made up of minute cells, loosely packed together; and that the cells at top and bottom, representing the lower and upper epidermis of the leaf, are devoid of the shading, which is meant to indicate the green colouring matter or chlorophyll within. An opening into the interior of the leaf will be seen at C; this is one of the stomata or organs for gaseous interchange, sugar-making, and respiration, and in the giving off of water vapour. At D may be seen a hair built up of four transparent cells, the two lower being traversed by a mycelial thread of the potato fungus. On the upper part of this hair, attached to the outside at E, may be seen one of the small branches of the fungus; this branch has burst and thrown out a mycelial thread from its side. Every fragment of the potato fungus is capable of growth, and of ultimately reproducing the parent fungus. The cells immediately under the true upper epidermis of the leaf at F are termed palisade cells; and their disposition in the manner illustrated serves to give the necessary firmness to the exposed upper surface of the leaf.

"If we now look within the fragment of the leaf we see transparent threads running between the small spherical leaf-cells: these are the spawn-threads or mycelium of the fungus. It should be especially noticed that wherever the spawn touches the cells it discolours them (as indicated by the darker shading), and causes putrescence by contact. If we again look at the palisade cells near G, we observe that a spawn-thread has pushed itself between them and between the cells of the upper cuticle,

and is emerging into the air. If we trace the spawn-threads to the stoma at H, we notice that a thread in its passage from the body of the leaf has blocked it up. This choking prevents the transpiration of water-vapour, and hastens putrescence. Two other threads have pushed themselves between the leaf-cells at G and A. When the larger of the emerged threads is traced upwards to K, a tree-like growth is noticed. The whole fungus is perfectly transparent, like colourless glass, and extremely fine and thin. If we now look at the branches, M M, we observe that each is surmounted by a transparent conidium, as at N N. It must also be noticed that all the branches are more or less constricted or jointed in a peculiar manner, as at O O; and that each joint has at one time carried a conidium, the lower conidia having been pushed off as the branches have continued their growth, as at P P. Sometimes a weakly impoverished thread, if grown in dry air, will quickly become strong and robust in growth if transferred to warm moist air, as in the thread illustrated at Q.

"If ripe conidia [N N] are placed in water, it will be noted that a differentiation of the contained protoplasm takes place; and that the interior mass of each conidium becomes divided into portions. These differentiated portions speedily emerge from the top of the conidium when placed on any moist surface; and each portion, now free, becomes quickly furnished with two extremely fine hair-like cilia or vibrating hairs. These secondary spores or zoospores are able to sail about in the slightest film of moisture. After a brief time the little motile zoospores rest and take a globular form. After a short rest the now quiescent zoospores germinate, each producing a germ-thread which can give rise to a new mycelium.

"Sometimes the conidium, which, when it bears zoospores, is really a sort of spore-case, sporangium, or zoosporangium, does not differentiate within, but germinates directly, giving a mycelial thread capable (like the thread from the zoospore) of carrying on the life of the potato fungus. It must be specially noted that water or moist air is essential for the existence of the fungus, for nearly every part speedily perishes in dry air, heat, or frost. When the conidia burst and set free the minute zoospores, the latter move over the damp surfaces of leaves. A zoospore swimming in an intercellular space is shown at R.

"One has only to imagine a large field of potatoes, with all the leaves moist and swaying backwards and forwards with the wind, to perceive that such a field, say on a warm misty morning or evening, would form a sort of continuous lake of moisture on which the zoospores could float from one plant to another. The conidia, with the contained zoospores, are also carried through the air in millions by the wind; they are so lightly attached to their supporting stems, and so extremely small and light, that the faintest breath of air wafts them away. Insects and other creatures also carry the conidia from place to place. The germ-threads from conidia or from zoospores may enter by a stoma, or may directly eat their way into the potato leaf.

"The fungus possesses such wonderful powers of spore production and rapid growth, especially when the air is moist and the temperature ranges from 60° to 70° Fahr., that in a few days one fungus growth will become ten thousand, so that the disease seems to almost suddenly cover the potato fields."

Smith believes that this potato-disease fungus can also multiply sexually, producing oospores like Pythium de Baryanum, mentioned above. There is reason, however, to doubt this, and instead of dormant hibernating oospores, it is likely that the mycelium may hibernate in refuse from diseased potato fields. Experiments at Kew have shown that hibernation of the mycelium can take place in the tubers. The practical importance of the last statement is manifest. A sudden outbreak of potato disease will not then be due necessarily to a great infection by conidia or spores, but may be due to the presence of latent mycelium in the tuber, called into active life by weather and other conditions that favour its growth. The importance of planting clean "seed" is further emphasised.

Phytophthora infestans attacks other plants in the Natural Order Solanaceæ.

Preventive and Remedial Measures.—1. Plant clean tubers, the tubers not having been saved from diseased fields. The tubers should have been stored in the best conditions. 2. The earthing-up of the potato drills with a deep covering of earth has been recommended, with a view to preventing the spores of the fungus from reaching the young tubers. 3. Growing the potato crop under such general sanitary and manurial conditions as will ensure to the fullest extent possible the healthy and vigorous development of the crop.

4. *Planting Varieties that have been known to be successful in resisting the Disease.*—It is known that certain varieties are, for the time being, exceptionally successful in resisting the attacks of the fungus. This valuable property is most generally found in some comparatively new variety—a variety recently raised from the seed—whose constitution and vitality of growth are unusually robust.

It is obviously advantageous, therefore, as a means of guarding against loss from the disease, to plant for the main crop such varieties as are at the time known to be the most successful in resisting the onslaught of the fungus.

Unfortunately there is a tendency in all the cultivated varieties of potatoes to lose vitality with long-continued culture. The "Champion," for instance, which for many years was almost disease-proof, at last fell an easy prey to the fungus. It is therefore desirable that the propagating of new and robust varieties should be liberally encouraged by potato-growers.

5. *Spraying with Bordeaux Mixture.*—The germination of the spores is prevented, and the spread of the disease kept in check. Further, the spray has an invigorating and stimulating effect on the leaves of the plant. The plants should be sprayed before the disease shows itself. If rain follows within some hours, the spraying must be repeated. The first spraying might be about the end of June or the beginning of July, followed by a second when the plants are well grown. In wet seasons there ought to be repeti-

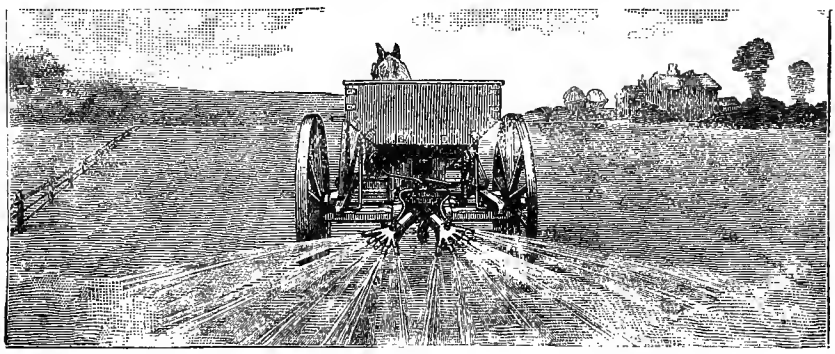


Fig. 622.—*The Strawsoniser at work.*

tions of the spraying. Bordeaux Mixture consists of copper-sulphate and lime in water. In Leaflet No. 23 of the Board of Agriculture the proportions of sulphate of copper and lime are given, and various modifications pointed out in detail. Recently Mr Pickering has given the following as the best recipe for 100 gallons of Bordeaux mixture:[1]—

"Dissolve 6 lb. 6½ oz. of crystallised copper sulphate by suspending it in a piece of sacking in two or three gallons of water. This must be done in a wooden or earthenware pail: zinc or iron must not be used. Take 2 or 3 lb. (not less) of fresh quicklime, slake it with a little water, and put it into a tub with some 120 gallons of soft water; stir several times and allow to settle till the solution is quite clear. Then run off 86 gallons of the clear lime-water and mix it with the copper sulphate, bringing the whole up to 100 gallons by the addition of soft water.

"This Bordeaux Mixture should be

[1] *Woburn Experimental Fruit Farm—Eighth Report.* By the Duke of Bedford and Mr Spencer Pickering. 1908.

tested to make certain that all the copper has been thrown down. The way to apply the test is to put a few drops of a solution of potassium ferro-cyanide into a white saucer with some water, and to drop into this some of the clear liquid

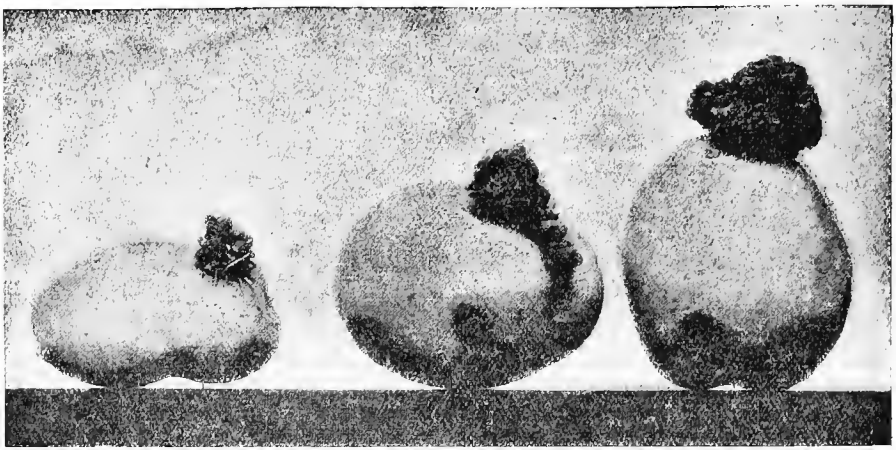


Fig. 623.—*Warty disease of potatoes; different stages of infestation.*

obtained after the Bordeaux mixture has been allowed to settle: any brown or red coloration indicates that there is copper in solution, and a little more lime-water must be then added to the mixture and the test repeated."

An excellent machine for spraying crops is the Strawsoniser, shown in fig. 622.

Warty Disease of Potatoes (Chrysophlyctis endobiotica, Schilb.)

This fungus does not consist of branching threads, but is a single-celled structure, a droplet of protoplasm, which enters the tuber, probably at an eye, and lives at the expense of the contents of the invaded cell. A yellow-brown discoloration accompanies attack, and externally the disease is recognisable by the warty outgrowth and distorted tubers (see figs. 623 and 624).

The fungus has swarm-sporangia and resting-sporangia. In the first case, a wall forms round the naked protoplasm of the fungus; within the wall the protoplasm breaks up into a number of swarm-spores, and these spores issue and spread the infection. The other sporangium is a resting-stage which tides the fungus over the winter, or till the conditions for its activity become favourable again. In this stage the protoplasm is protected by a stout wall (see figures). The disease may attack the young sprouts, or later, the tubers.

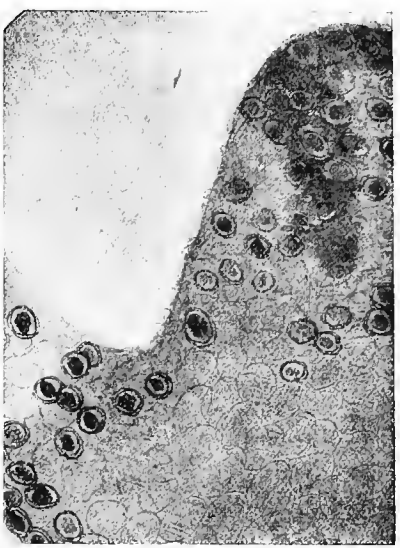


Fig. 624.—*Warty disease in potatoes; section through malformation to show its resting sporangia.*

The warty outgrowth ceases to grow when the potatoes are lifted.

Treatment.—Potatoes should not be planted for at least two years on land

that has shown the disease. Crucifer or grass or Umbelliferous crop plants are not attacked. Diseased tubers should not be used for seed, but infested tubers should be collected and burned. Leaflet No. 105 of the Board of Agriculture treats of the Warty Disease of Potatoes, and this disease is scheduled in the Destructive Insects and Pests Act of 1908.

Onion Mildew (Peronospora schleidenii, Unger).

Yellowish patches show on the leaves, which ultimately coalesce into greyish-lilac patches. An early symptom of attack is the marked increase in length of the neck of the onion. The mycelium living in the leaf sends threads out through the stomata; these mycelial threads branch and give off the conidia or spores. If the disease show early, then on account of destruction of leaf the bulbs fail to develop. This fungus also produces oospores, which lie dormant for a time, and can, on germination, set up a new infection.

Treatment. — Remove and burn infested plants. If allowed to lie, the oospores will infect the soil. Dust the crop when the plants are covered with dew with 1 part of powdered quicklime to 2 of sulphur.

White Rust of Crucifers (Cystopus candidus, Pers.)

This Phycomycete attacks cabbage, radish, and wild crucifers such as shepherd's purse, whose leaves, stems, and fruits often show bad attack and accompanying distortion. Glossy white patches show on the parts attacked. The skin of the plant ruptures, and chains of conidia show on the outside in the form of a white powder. These give rise to zoospores, which infect new plants. Oospores are formed later (not in the case of shepherd's purse), and oospores attack seedlings in the next season.

Treatment. — (1) Keep down shepherd's purse. (2) Remove and burn diseased leaves, and burn distorted stems so as to destroy the oospores.

THE ASCOMYCETES.

This is a family of Fungi with a septate mycelium. The name is given from the spores being enclosed in sacs called asci. The family contains both saprophytic and parasitic members.

The Mildews.

The term mildew is popularly applied to many fungi that may not have any definite relationship to one another. Botanically the term is applied to the Erysipheæ, a group of Ascomycetes parasitic in habit. A great characteristic, too, is that the mycelium of the fungus is external, and the fungus would therefore be easy to reach with treatment, only the worker is baffled often by the widespreadness of the disease. The mildew fungi send suckers from the external mycelium into the host plant, tapping it for food-material. Typically there are two modes of multiplication. First, conidia are produced during the summer, which conidia being scattered spread the infection to other plants. Secondly, in autumn small dark spots show on the mycelium; these are fruits which contain one or more asci, the spores from which are resistant to conditions that generally would kill the mycelium and the conidia; after resting during the winter, the ascospores germinate and set up the disease. In some of the Erysipheæ both the conidial and the ascospore stage have not yet been demonstrated, and this is the case with

Turnip Mildew (*Oidium balsamii*, Mont.)—This fungus is only known in one reproductive stage, the conidial. The host plants are crucifers, like turnip and swede; but plants outside Cruciferæ are also attacked. The mycelium is found all over the leaves, covering them often so completely as to choke up the stomata; respiration, carbon-assimilation, and transpiration are interfered with, and the tubers fail to fill. The disease begins towards the end of July, and by the end of August the plants may be white. The whiteness is due to a mass of mycelium, from which threads are sent up that end in barrel-shaped conidia. The further stages in the life-history are not known.

Treatment.—Stimulating dressings to tide the plant over the early stages of attack. Spraying with Bordeaux Mixture, care being taken that the under sides of the leaves are reached by the spray. Cucumbers and vegetable-marrows also

fall before this fungus. Should Bordeaux Mixture be used in their cases, care should be taken that the delicate blossom is not harmed, and, further, the spraying should not be done when the fruit is ripening. Powdered sulphur or washes containing sulphur are also useful against mildews.

Mildew of Grasses (*Erysiphe graminis*, DC.)—The lower leaves of cereals and grasses—specially where the growth is rank—sometimes show irregular brown-white spots, due to the mycelium of this fungus. During the summer conidia are produced, which are scattered and spread the infection. Later in the year brown somewhat flask-shaped structures (the perithecia of the books) appear: each contains asci, whose spores, passing the winter in leaf and straw, germinate in the next spring.

Mildew of Pea (*Erysiphe martii*, Lév.) — This enemy of leguminous plants, worst in dry seasons and on late varieties, is sometimes so destructive to the leaves that pods fail.

Mildew of Rose (*Sphærotheca pannosa*, Lév.)—Leaves, shoots, and flower-buds may be covered with a white or a greyish-white felt or film of the mycelium of this fungus. The leaves as a result pucker and fall early. In the summer, spread is by conidia. Later, round dark-coloured flasks appear, each with one ascus. The ascospores, after winter, give rise to a new mycelium. The disease is kept in check by spraying with a solution in water of liver of sulphur, ½ an ounce in a gallon of water, stronger than this if the leaves are not tender.

Gooseberry Mildew (*Microsphæria grossulariæ*, Lév.)—The mycelium is found on the leaf, giving rise to white patches. On magnification the powdery material on the leaf is found to consist of conidia. An ascospore stage is also found. The leaves fall early, and the fruit is small. The bushes, after several attacks in successive years, may die.

Treatment.—Burn all fallen infested leaves to destroy the ascospores. Deep digging about the bushes will bury the spores on the ground. Against the mycelium the bushes should be sprayed with 1½ lb. of sulphate of potassium to 50 gallons of water.

American Gooseberry Mildew (*Sphærotheca mors-ursæ*, Berk.) — This is a far more harmful fungus than the last, for it attacks leaf, shoot, and fruit. There have been outbreaks of this fungus in several parts of England, and as a result the disease has been scheduled in the Destructive Insects and Pest Order, 1908. Full details as to life-history and instructions as regards treatment are given in the newly issued Board of Agriculture Leaflet, No. 195. Red currants have been attacked in Ireland. It is possible that black currants and raspberries may also be attacked.

The two forms of Gooseberry Mildew are shown in fig. 625.

Winter Rot of Potatoes (Nectria solani, Pers.)

This disease is one which attacks stored tubers. Tubers are stored with the mycelium present, the result of infection by spores in the soil; but whether or no the disease develops, so as to give rise to sunken shrivelled portions on the outside of the tuber, depends on the conditions. The conditions favouring the fungus are the storing of the potatoes before being well dried, and then the absence of aeration.

As the disease makes progress, white mycelium is seen to be present on the shrivelling areas of the tuber. Spores produced by this mycelium spread the disease from tuber to tuber until the potato is ruined, the decay being hastened by secondary parasites. A second kind of spore is produced in the next season from little red warts on the skin of the potato, and the spores lying in the soil infect the next crop.

Treatment. — Have well-ventilated pits and store in dry condition. Powdered sulphur, 2 lb. to the ton, dusted over the tubers, kills the fungus.

In Leaflet No. 193 of the Board of Agriculture it is advised that kainit be applied to infected land. "When land is infected this manure should be used in preference to sulphate or muriate of potash; but the quantity should not exceed 5-6 cwt. per acre, or the quality of the potatoes may be injured. Kainit may be applied in the drills before planting; but in this case, where it is required both as a manure and a fungicide, it would probably be better to apply it as a

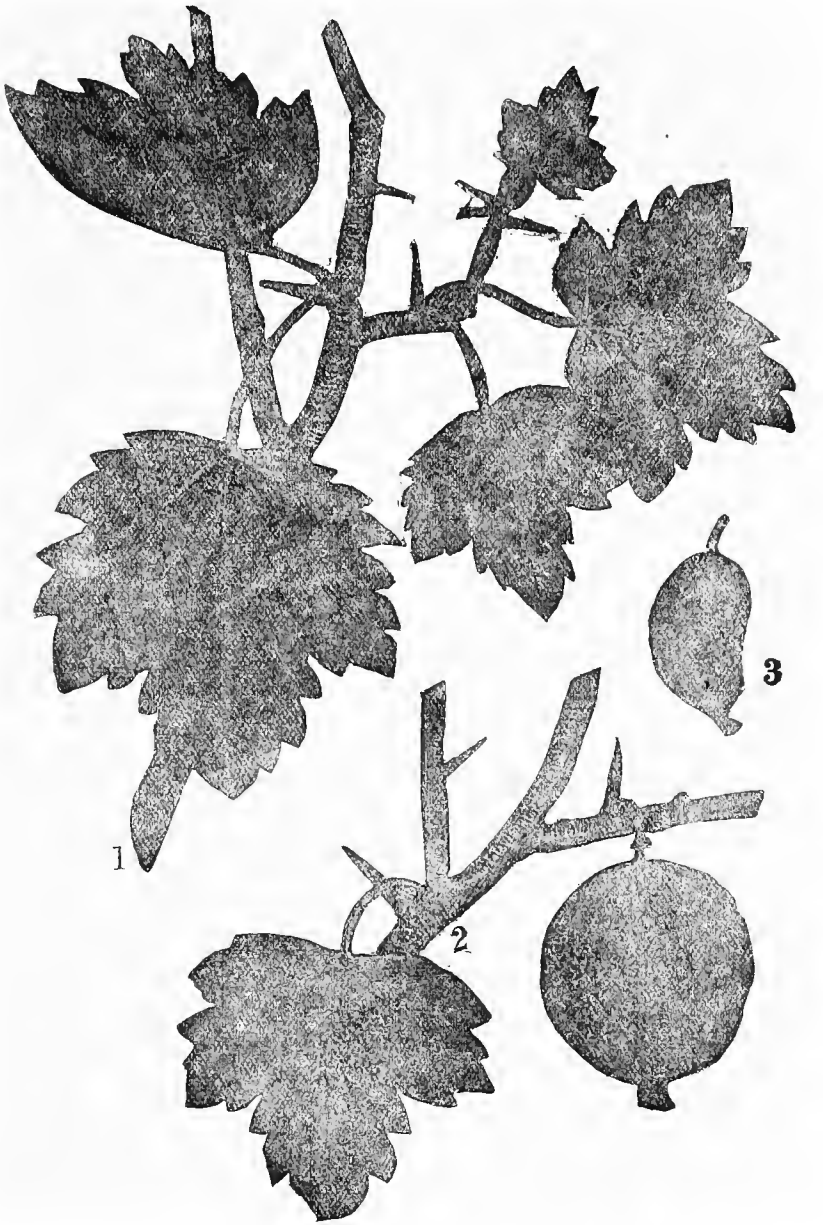


Fig. 625.—1, *Gooseberry mildew*; 2 and 3, *American gooseberry mildew.*

top-dressing before the horse-hoe is used for the last time.

"If the land needs potash, and especially if the potato crop is to be followed by a crop likely to be benefited by potash, *e.g.*, barley and mangolds, a dressing of kainit may be applied to the infected land as soon as the potatoes

have been lifted. If potash is not required, and if the land is likely to be benefited by lime, then it would be desirable to dress the affected field with 1 to 3 tons of lime per acre. See also Leaflet 170 on Liming of Land."

Ergot (Claviceps purpurea, Tul.)

This fungus is parasitic in the flowers of cereals and grasses, where as a result of its presence the ovary is destroyed, there being of course no fruit or grain. The ergot grains seen in autumn projecting from the grass heads are black or black-blue in colour and ribbed. Each grain is the result of a compacting of mycelial threads, and is a hard structure fitted to act as the dormant winter stage of the fungus. The grains fall away from the host plants and lie till the next season, when, in the presence of favourable conditions, they send out branches that end in swollen heads. Each head has all round it internally, but with openings to the outside, a series of flask-shaped structures. These contain asci with ascospores. The ascospores escape and reach the flower of a grass; here they germinate, and a mycelium is formed which penetrates the ovary and lives at the expense of the host. During the summer, conidia are produced in great numbers. These are carried by insects to other grass flowers, and so the disease spreads. At this time a quantity of "honey-dew" is secreted, and this may be attractive to insects, which carry away conidia attached to their bodies. As the season goes on the mycelial threads compact into the hard grain with which we started the life-history.

The ergot grain contains a poisonous principle, and cases of ergot poisoning are found on the Continent where bread has been made of flour that contained in it ground-up ergot. Where pasture grasses are ergoted the flowering heads should be cut, raked together, and burned. Only clean samples of grain or grass should be sown. It is not at all uncommon to find the wild grasses along roadsides ergoted.

Phoma.

Potter has described a species of Phoma which attacks the roots of swede. The fungus is probably a stage in a more complex life-cycle, part of the life-history being spent away from the root.

The disease shows at the upper part of the swede; depressions appear from the drying up of attacked cells. Black spots appear at the outside, and from these points the spores are given off.

The Uredineæ or Rust Fungi.

These are parasitic forms in which there are several kinds of spore produced in the same life-history: the mycelium is generally intercellular.

Black Rust of Wheat (*Puccinia graminis*, Pers.)—A wheat plant suffering from this parasite would present early in the summer a somewhat yellowish appearance, and soon, on careful looking, long rusty spots would be seen on leaf and stem. Under the microscope these are seen to be places where the epidermis has been broken, and where numerous orange-coloured spores are hanging out (fig. 626, p. 420). These spores, known as uredospores, pass to other wheat plants and send out germ-tubes or threads which enter the new host by a stoma, or by directly boring through the epidermis. This freshly infected plant will soon harbour the developed mycelium of the rust fungus, from which uredospores will be given off in turn. Towards the end of the summer this mycelium on the wheat produces a different kind of spore—the teleutospore. This teleutospore is a two-celled spore, and is dark-brown to black in colour. The teleutospores hibernate over winter, and in the next spring germinate by sending out two germ tubes, the upper ends of which become partitioned. Each jointed portion gives rise to a conidium or spore, which in order to germinate must reach not a wheat plant but a barberry. In the barberry as a result a mycelium is developed, which gives out, through the ruptured upper skin of the barberry leaf, conidia, and from the broken lower skin spores called æcidiospores (fig. 627, p. 421). The destiny of the conidia is unknown, but the æcidiospores on reaching the wheat plant germinate and give rise to the mycelium in wheat with which we started the life-history.

In this life-history it will have been noted that two hosts were necessary for its completion. It is possible, however, that the barberry is not absolutely necessary, and Eriksson has suggested that this parasite in wheat can be transmitted to the grain, where as a "plasm" it lies dormant in the embryo, and that in the presence of favouring conditions the uredo-mycelium can be developed after the germination of the seed and the growth of the plant.

A fact of great interest, proved by the researches of Eriksson and Henning, is that while Black Rust is parasitic on wheat, barley, and oats, the disease cannot pass from one to the other—*i.e.*, the uredospores of wheat cannot set up the infection in barley or oat, and the uredospores from barley cannot set up the disease in wheat, and so on. Under the microscope these varieties cannot be distinguished in form or appearance, but they are "biological varieties." The practical importance of this is further seen when we know that while Black Rust occurs on various wild grasses, the uredospores from these cannot infect wheat.

Yellow Rust of Wheat (*Puccinia glumarum*, Schm.)—This rust is also known as Spring Rust, as it appears earlier than the last. According to Biffen,[1] and opposed to the popularly accepted view, this is the most common and important of the rusts in this country, spoiling leaf and shoot and flower-envelopes and grain.

The life-history of the wheat plant is the same as given for Black Rust, uredospores and teleutospores being produced. No second host, however, has been found in the case of this rust corresponding to the barberry in the other, and it is known that the teleutospores are not necessary; the uredospores can hibernate, and can set up infection directly in wheat in the next season. We have here also "biological varieties," one being found on wheat, another on barley, a third on rye.

Treatment.—Immense loss results from rusted crops in other parts of the world. In Britain we have no estimate, but the lessening of feeding and assimilative area represented in the destruction of leaf and shoot means poorer harvest and shrivelled grain. Apart from the advantage of good cultural operations, practically nothing can be advised as remedial. It is felt that the rust problem throughout the world is most likely of solution by the breeding of rust-resistant varieties. Experimenters have been active with this end in view for a good many years now. More recently, the interest in, and the wide acceptance of, the principles underlying Mendel's Law—by which plant-breeding is no longer the lottery that it seemed to be, but a thing of definite system—have stimulated experiment, and have raised hopes that at no distant date there will be on the market varieties of cereals immune to rust.

Other Rusts.—The rust of beans (*Uromyces fabæ*, Pers.) attacks the leaves and stems. Uredospores and teleutospores are produced, but there is no intermediate host. The Uromyces of the pea has two hosts, one the pea and the other a wild spurge.

Two troublesome rusts in gardens are Chrysanthemum Rust (*Puccinia hieracii*, Mart.) and Hollyhock Rust (*Puccinia malvacearum*, Mont.) In the first its whole life-history is completed on the one species of host, there being no second host with æcidiospores. The disease is spread in the summer by uredospores, and later the teleutospores are produced. The disease also affects wild composites—*e.g.*, hawkweed and burdock. Spray with sulphide of potassium, half an ounce to a gallon of water. The leaves with teleutospores should be collected and burned to prevent infection in the next year.

In Hollyhock Rust, leaves, stems, sepals, and ovary are all attacked. There is no second host, and only one kind of spore is produced—viz., teleutospores. The little wart-like swellings which bear the clusters of teleutospores are grey-pink at first, but later dark-brown or black. If fading diseased plants be pulled and burned, there will be no disease in the next year. As a preventive measure spray with Bordeaux Mixture. Do not use seed from plants whose fruits have been rusted.

[1] *Journal of Board of Agriculture*, July 1908.

The Ustilagneæ.

This is a set of parasites interesting to the agriculturist from their attacks on cereals and grasses.

Smut of Oats (*Ustilago avenæ*, Jens.)—This parasite attacks the ears and invades the ovary, feeding off the reserve material which would normally have been laid up in the grain for the use of the embryo plant. In the ovary immense quantities of minute spores are produced, these giving the characteristic dark-brown sooty appearance characteristic of the spoilt oat-ears in July or earlier: chaff and grain are both destroyed. The spores are carried about, but infection of other plants does not take place at this stage. Under the microscope the spores are seen to have two coats, a somewhat rough dark-brown outer coat and a more delicate inner one. Infection of the oat plant can only take place in the seedling stage. When the oats are sown, spores attached to the grain germinate, and the germ-tube of the fungus invades the seedling. The fungus mycelium grows up with and branches in the host plant, ultimately passing into the ear, and giving rise to the spores which break through the epidermis of chaff and ovary and show on the outside.

Treatment.—Soak the seed oats in warm water thus: Place the grain in a sack and steep in a tub of water, with the temperature at 121° Fahr. to warm the seed; then soak for five minutes in water at a temperature of 131° Fahr. Remove and plunge the seed into cold water. Dry and then sow. Or dissolve 1 lb. of copper sulphate in a gallon of boiling water in a *wooden bucket* or *a copper pan*. Allow to cool. Empty a sack (4 bushels) of corn on to the barn floor and spread out. Pour the solution of copper sulphate over this, turning the seed over to make sure that all be wetted. Dry and sow. Or make a solution of 1 pint of 40 per cent formalin in 36 gallons of water. Place the seed in a bag, and allow to dip into the formalin solution for ten minutes. Dry and sow. A pint of the formalin costs 2s., and would serve for between 40 and 50 bushels of grain.

Wheat Smut (*Ustilago tritici*, Jens.)—This smut attacks the grain and the chaff. The spores are shed before the crop is harvested. A very important difference in life-history as compared with the smut of oat has to be noticed. Infection does not take place in the seedling stage in the next season, but Brefeld's experiments show that in the season in which the spores of wheat smut are shed the spores are carried by wind, &c., to wheat *flowers* and there germinate, the mycelium reaching the ovary. The mycelium hibernates inside the seed and develops when the seed is sown. If Brefeld's experimental work be accepted, then the "steep" treatment or "pickling" will not be efficacious as applied to wheat seed.

Naked Barley Smut (*Ustilago nuda*, Jens.) and **Covered Barley Smut** (*Ustilago tecta*, Jens.)—These two kinds of smut are found on barley: the spores of naked smut come to the outside and are spread before harvest. Infection is, as in the case of wheat smut, through the flower, the mycelium hibernating in the grain. In covered smut the spores remain within the chaff until the crop is harvested.

Bunt of Wheat (*Tilletia tritici*, Bjerk.)—This fungus enters the young wheat plant by germ tubes from conidia in the soil. The spores of the fungus are found in immense numbers in the ovaries of the infested plant. These spores do not show on the outside, but on crushing a diseased grain the olive-black spores escape. They have a disagreeable odour, and this, as well as the dark colour, is imparted to the flour when diseased grains are present in a sample of wheat and are ground up.

When a bunt spore germinates, it sends out an elongated mycelial thread, from the apex of which arises a tuft of secondary spores. These secondary spores become connected one with the other; those that join in pairs germinate by giving out a delicate germ-tube which enters the wheat seedling and grows up with it, giving rise to the fungus mycelium, whose spores are formed in the ovary.

Wheat plants attacked by the fungus of bunt are generally in their early stage a deeper green or blue-green, and appear more luxuriant; later, the ears are erect

and rigid, the chaff is pale and bleached looking, and the grains are swollen and out of shape. Inside the grain is the mass of black spores.

Treatment. — The treatment is the same as that recommended for smut of oats.

Hyphomycetaceæ.

A number of fungi, probably representing for the most part stages in the life-history of higher fungi, come under the above title. The following are examples met with on agricultural plants.

Early Blight or **Potato Leaf Curl** (*Macrosporium solani*, M. and E.)—This fungus may attack the potato when the plants are young (5 or 6 inches high), and especially in dry weather. The disease begins at the base of the stem, and the mycelium spreads to the leaf. The leaves curl, light-brown patches of dead tissue show, and the rest of the blade is sickly yellow; in time the stem collapses. Spindle-shaped conidia or spores are produced which break through the tissue: these spores, which are brown in colour, are partitioned. The mycelium may spread to the tuber. Tubers of badly infested plants remain small from the destruction for feeding purposes of the leaves above. Massee holds that the above-ground parts cannot be infected by the spores, in which case the spraying with Bordeaux Mixture would not directly affect the fungus.

Treatment.—As the disease appears from the presence of the mycelium in the tuber or from spores in the soil, burn diseased shaws; do not plant tubers from a diseased area.

Potato Scab (*Oosporascabies*, Thaxter). —This is a disease of the tubers: the mycelium is superficial, and gives rise to scabs or patches, which in time may run together and the potatoes be cracked and spoiled for the market. The potatoes, however, may be eaten. In the multiplication of the fungus, conidia are produced at the apices of delicate threads.

Treatment.—Do not follow potatoes where the disease has been present with another crop of potatoes, nor with such crops as swede, cabbage, carrot, beet, as these may also suffer from scab. A cereal crop may be taken in safely.

Do not use "scabby" potatoes for "seed" unless treated by steeping them for two hours in a solution made by mixing 1 pint of commercial formalin (=formaldehyde, 40 per cent) in 36 gallons of water. The tubers are allowed to dry and are then planted.

The Slime Fungi or Myxomycetes.

These are chiefly saprophytes, but the one causing club-root in cruciferous plants—viz., *Plasmodiophora brassicæ*—is a parasite. They are characterised by their protoplasm being naked, not enclosed, as it generally is in plants, within a wall or walls: the naked protoplasm is known as a plasmodium, and is capable of an irregular amœboid creeping movement.

Finger-and-toe or Club-root (*Plasmodiophora brassicæ*, Wor.)—This enemy (fig. 628, p. 422) attacks turnip, swede, cabbage, especially, but also cauliflower, brussels sprouts, broccoli, rape, mustard, kohl-rabi, charlock, wallflower.

Attack is in the young stage, and is marked by sickly foliage; the tops of the attacked turnips become yellow and droop; as the disease advances the bulb rots, and with its destruction an offensive odour is given off. If a thin slice be cut with a razor through one of the swellings and placed under the microscope, the cells would be found to contain a turbid brown slime which would either fill the cells or stretch across them in bands. This is the plasmodium of the fungus, which feeds at the expense of the cell contents and causes the tissue of the root to break down. As the season goes on a change comes over the masses of brown plasm; these break up into numbers of small spores, each surrounded by a thick wall. These spores are resting-spores, and as such they are resistant to outside influences. The spores are colourless if examined individually, but are yellowish in the mass. They may remain all the winter in the affected turnips, or lying in the ground or on the dung-heap. On germinating after the winter the wall ruptures, and the protoplasm issues as a tiny droplet provided with a cilium or lasher, by which movement is possible. This moves about in search of a host, gaining entrance by a young rootlet, or

by a root-hair, or through a wound. Inside the root the plasmodia move from cell to cell, and the characteristic swellings appear. Other enemies may assist in the destruction of the bulbs, which become the happy hunting-ground of insects and their larvæ, and millepedes and eelworms.

Treatment. — General principles: Keep down cruciferous weeds. Try to prevent diseased material from being carried to uninfected ground. Specially do not feed the diseased roots to stock at the homestead, else the spores of the fungus will get into the dung, which later may be carried to the fields where turnips will be grown. Finger-and-toe does not attack grasses, hence infected dung may be used on a permanent grass-field. Potatoes, cereals, and mangolds can be grown on finger-and-toe infected ground. The spores of the fungus can lie dormant for a long time, therefore lengthen out the rotation where the disease is prevalent, so that the turnips be separated by, say, eight years. Let the headlands be watched, so that the disease may be stamped out on its appearance. Apply lime, unslaked or recently slaked, some time before the turnip crop is taken.

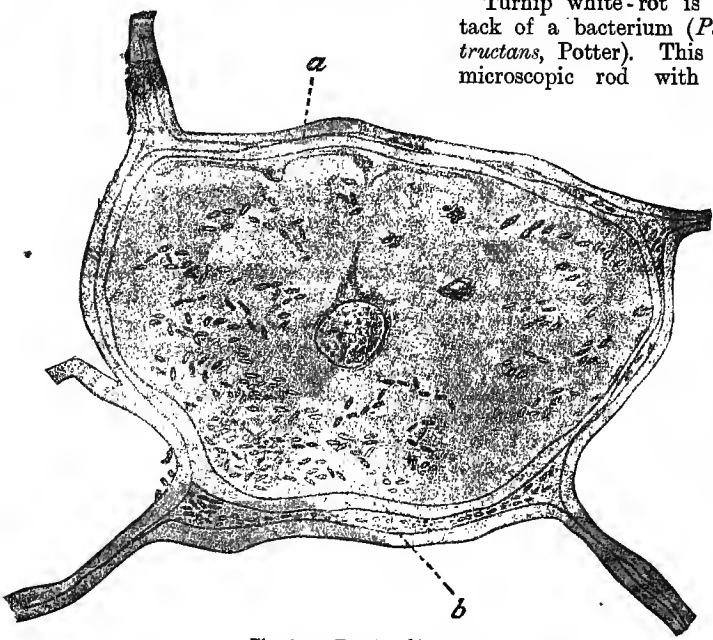


Fig. 629.—*Turnip white rot.*

A cell from a turnip infested by *Pseudomonas destructans*. The bacteria are seen in the cell-cavity and along the track of the middle lamella. At *a* the cell wall is beginning to separate along the middle lamella. At *b* the dissociation is more strongly marked. (After Potter.)

BACTERIA.

The diseases of plants caused by bacteria are, as compared with those due to fungi, very few.

Turnip white-rot is due to the attack of a bacterium (*Pseudomonas destructans*, Potter). This bacterium is a microscopic rod with rounded ends (fig. 629). The rot induced is the work of a cytase ferment produced by the bacterial activity. The ferment acts on the walls of the cells of the turnip, causing them to swell and soften; the central part of the common walls of the cells is dissolved, and so the cells fall apart and the whole tissue becomes disorganised. The bacteria gain access to the root by a wound.

Black-rot of Cabbages (Pseudomonas campestris, Smith).

This disease is also bacterial in origin. Cultivated crucifers are the plants attacked. Leaflet No. 200 of the Board of Agriculture describes the disease and treatment.

The bacteria enter the leaves by water-stomata or by wounds, or enter the roots through wounds. The bacteria spread by the vascular bundles to the stem, and thence to other leaves. A characteristic symptom is the blackening of the veins.

DESCRIPTION OF FIGS. 626, 627, 628, pp. 420, 421, 422.

Fig. 626.—*Rust in wheat.*

1 and 2, The æcidia or cluster-cups on barberry leaf.
3 and 4, The spermagonia on the barberry leaf.
5, A section through an attacked barberry leaf.
A, An æcidium with æcidiospores escaping.
B, A young cluster-cup or æcidium.
C, Vein of leaf.
D, Spermagonia with escaping conidia.
E, Younger stage.

In 5, the threads of the fungus mycelium can be seen between the cells of the leaf.

Fig. 627.—*Rust in wheat.*

1, 2, 3, Fragments of leaf of wheat invaded by uredo mycelium.
4, The same under a higher magnification to show the mycelium and the numerous uredospores at the ruptured skin of the wheat leaf.
5, Germinating uredospore.
6, 7, 8, 9, Wheat showing later stage of attack: in 9 the mycelium is seen and many teleutospores.
10, Magnified teleutospores as seen in autumn and winter.

Fig. 628.—*Finger-and-toe in turnips.*

1, 2, 3, Young plants distorted by the attack of the finger-and-toe parasite.
4 and 5, Sections through a piece of turnip: in 5 the slime is seen stretching across the cells.
6, The plasmodium has divided up into spores.
7, Spores under high magnification.
8, Spores germinating.

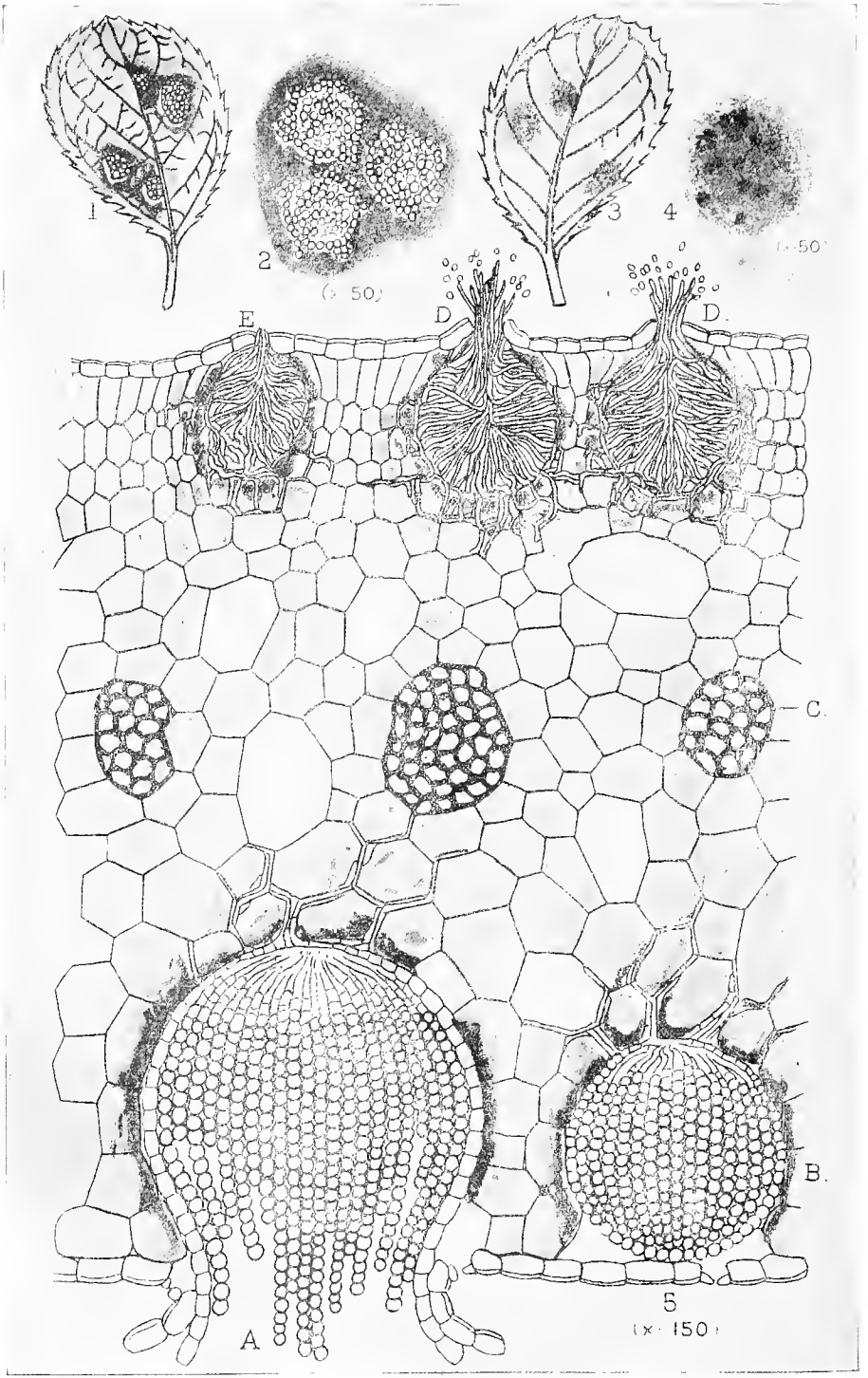


Fig. 626.—*Rust in wheat*—see p. 414.

Cornell University Library

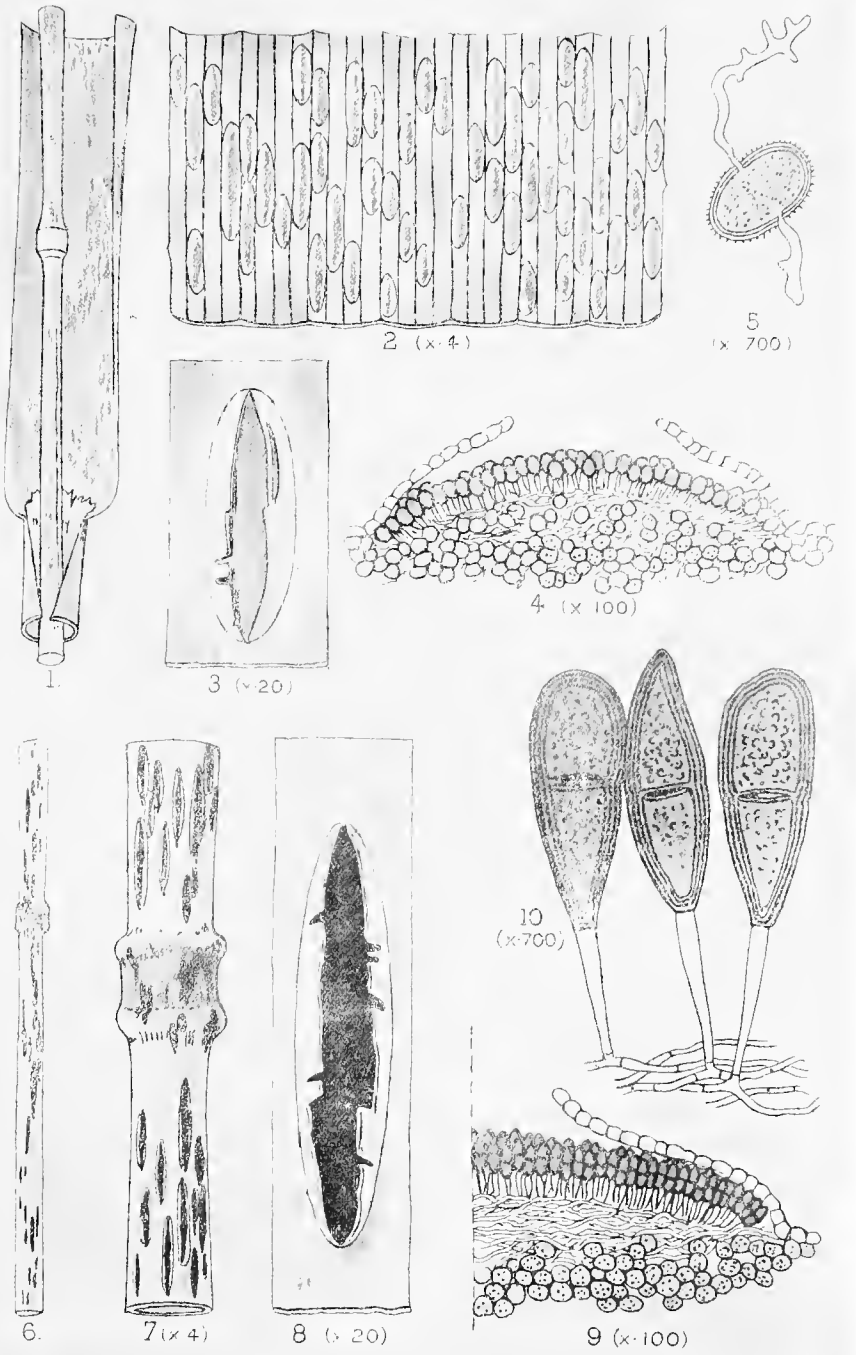
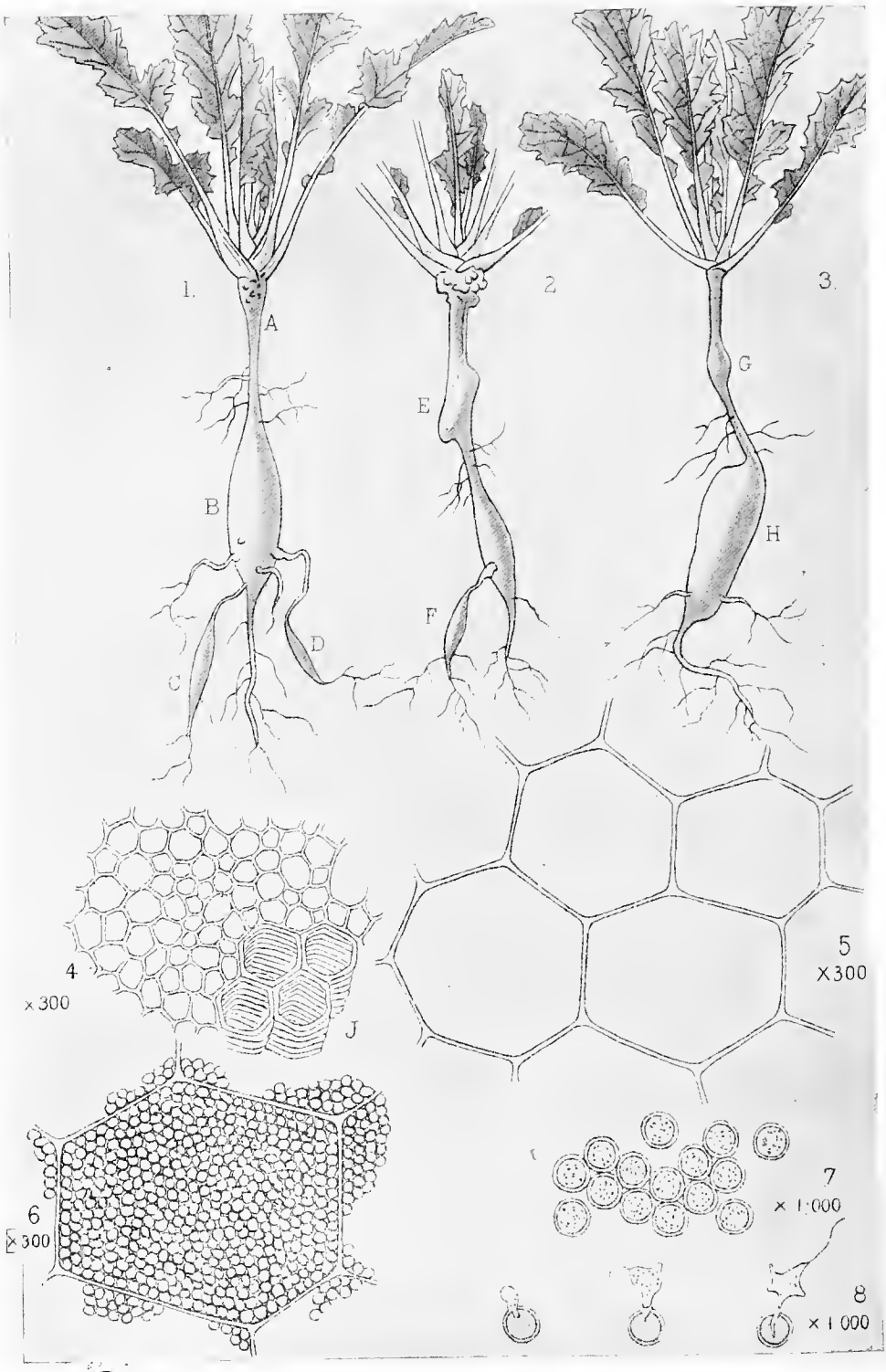


Fig. 627.—*Rust in wheat*—see p. 414.

Cornell University Libraries



Cornell University Library

Fig. 628.—*Finger-and-toe in turnips*—see p. 417.

DODDER—A PARASITIC FLOWERING-PLANT.

Dodder or Cuscuta is a genus of flowering-plants belonging to the Natural Order *Convolvulaceæ*. Dodder is harmful in a crop because of its parasitic habits, the host plant perishing owing to the drain upon its strength from loss of sap drawn away by the parasite.

Typically, an independent flowering-plant feeds by its roots and its green leaves. By the roots water is taken in and mineral matter in solution; by the leaves CO_2 is taken in, and in the presence of certain necessary conditions, one of which is the possession of chlorophyll or leaf-green, the CO_2 taken in is broken up and made use of in the manufacture of carbonaceous food-material. A dodder plant has no roots, and, once it has attached itself to a host, no connection at all with the soil; neither have the dodders any chlorophyll—or at most the merest trace. The dodder plants therefore are complete parasites, fixing themselves to, and feeding entirely at the expense of, the host plant. Attachment to the host is secured by means of haustoria or suckers, which are sent into the sap-conducting tissues of the plant (the vascular bundles), and by them the host is tapped for food-supplies.

There are four British species of Cuscuta, but at least other three species have been found, introduced in seed from foreign countries. The British species are as follows:—

Clover-Dodder (*Cuscuta trifolii*, Bab.)—It has very delicate thread-like stems, brownish-red in colour; it produces clusters of small whitish flowers. The fruit of each flower is a two-chambered box, each chamber holding two seeds. The seed of dodder is in almost all cases smaller than the seed of the crop plants. The seed of *C. trifolii* (fig. 399, p. 89, vol. ii.) measures less than one millimetre in diameter; it is dim, not glossy like the clover seed, and if examined with a lens will be seen to be irregularly pitted and somewhat flattened and angular, owing to pressure in the seed-box. Dodder seeds contain, in addition to the embryo plant, a store of reserve. In this reserve the embryo lies coiled in a spiral. *C. trifolii* attacks specially red clover and lucerne and other leguminous plants; but in other European countries there are records of attack on beet, potato, and carrot.

Lesser Dodder (*C. epithymum*, Murr.)—This dodder is very close to the last. It flowers from July onwards; the flowers vary somewhat in colour. Its host plants are thyme (hence the specific name), whin, and ling.

Greater Dodder (*C. europæa*).—This is a larger plant, with thicker yellow-red stems. Its host plants are the stinging-nettle, hops, and some leguminous plants; it has proved harmful, too, to young osiers in plantations. It is found from near the north of England southwards, but is not common.

Flax Dodder (*C. epilinum*, Weihe).—The stems of this species have a trace of green; the flowers are whitish. The host plant is flax. Although as big as the last, it is not such a strong plant.

Life-history.

Clover-seed may contain in the sample sown some seeds of dodder. When the Cuscuta seed germinates, the embryo grows out; the lower radicle end of it is thickened, and gives support to the whip-like stem that is growing into the air. This aërial portion twines round a clover plant and sends suckers into it. Once attachment is secured the dodder loses all connection with the soil. Unless the dodder succeeds in reaching a host it dies soon after the reserve laid up for it in the seed has been exhausted. If it fix itself, however, after feeding for a short time, it sends out branches which reach and twine round other plants, and so the parasite spreads. Some species of dodder have a greater capacity for branching and spreading in this way than others. It has been recorded that spreading so, a single Cuscuta plant can in a growth period of three months spread to, twine round, and destroy the host plants over an area equal to about 30 square yards.

In addition to this mode of spread, dodder has another mode of multiplication, as any pieces of cut or broken-through stems can in favourable conditions give rise to a new plant. Reproduction is also by seed which may be harvested with that of the crop plant so that the seed sample is impure, or may fall away from the ripe dodder fruit and lie dormant in the soil.

Treatment.

Although dodder is not the pest in Britain that it is in other European countries, yet botanical records and reports show that samples of seed contain, and that not rarely, dodder seed as an impurity. Seed in which dodder is found should be sieved—*i.e.*, the impure sample should be shaken in a sieve or set of sieves whose meshwork is fine enough to keep back the seed of the crop while allowing the seed of the parasite to pass through. The dodder seed thus separated out should be burned. The *Journal of the Board of Agriculture* some time ago quoted a recommendation from the *American Agriculturist* as to the making of a suitable sieve. "Make a light wooden frame, about 12 inches square and 3 inches deep, and tack over the bottom of it a 20-mesh wire screen (mode of No. 32 English gauge, round wire). In this one quarter to one half pound of seed should be placed and vigorously shaken for a half a minute. A man should be able to deal with from 5 to 10 bushels of seed per day." Samples of clover or other seed containing dodder should never be sown.

If dodder be present in a field, it should be annihilated with the plant round which it has twined. The destruction of the dodder should take place at once and in the spot where it is found; the best means is by fire.

Instead of firing the infested plants, some prefer to kill the dodder by putting over it some material which will kill the dodder. Several different materials are used, and a French worker, quoted by the author of an article on dodder, in the *Journal of the Board of Agriculture* for September 1906, praises above all calcium sulphide. It should also be kept in mind that feeding plants infested with dodder to stock is attended with danger, for it has been shown that dodder seeds can pass through the alimentary canal of stock without losing its powers of germination. In cases of very bad infestation the surface-soil should be buried deeply, and no leguminous crop taken for two years.

THE SMALLER MAMMALS IN RELATION TO FARM LIFE.

The Mammals which enter at all into the life of the farm are embraced in the following orders:—

Ungulata, or hoofed mammals — *e.g.*, horse, pig, ox, sheep, goat, deer.

Carnivora—*e.g.*, dog, fox, cat, weasel, stoat, polecat, badger, otter.

Rodentia, or gnawers — *e.g.*, rabbit, hare, rats, mice, voles, squirrel.

Insectivora — *e.g.*, hedgehog, mole, shrew.

We are concerned here with the smaller and non-domesticated mammals.

CARNIVORA.

These are typically flesh-eating forms which prey on other animals. They have small incisor teeth, but the canine teeth are strong, and some of the cheek teeth are modified for cutting; the toes are always clawed.

Fox.—The dog-like carnivores—*e.g.*, the fox—have the claws non-retractile. The fox (*Canis vulpes*) is in colour well suited to its environment. It may live above ground in hollow trees, or under old tree roots, or amongst heather, but, typically, it shelters in holes below ground — holes made by other animals — *e.g.*, badger and rabbit, or "earths" shovelled out by its clawed fore-limbs. To facilitate escape there may be several passages from the shelter place of the fox. There is one litter in the year, in the spring, 3 to 6 or 7 cubs being produced.

The senses of the fox are keen, especially sight and smell, and his "intellect" generally has been sharpened as a result of the struggle for existence. "More elegant than his relatives in mien and bearing; sharper, more prudent, calculating, and adaptive; of strong memory and sense of locality, resourceful, patient, resolute; equally skilled in jumping, slinking, crawling, and swimming, he seems to unite in himself all the qualifications of a perfect highwayman, and when his lively humour is also taken into account, produces the impression of a highly-educated artist in his own line." The food consists of game-birds, poultry that are not protected, hares, rabbits, and to a very great extent field-mice; insect grubs are also eaten.

Wild Cat. — The cat-like carnivores have retractile claws, and have rounder skulls than the dogs. Characteristic also are the rough tongue and the flexible backbone. The wild cat (*Felis catus*) is still to be found in some places in Scotland. In colour it is grey or yellow-grey with black stripes. It is larger than the domestic cat, while its tail, unlike that of the domestic cat, does not become thinner to the tip. In relation to the farmer the wild cat may be said to be useful in its destruction of mice, but it can be harmful among young deer and in game preserves.

Other Small Carnivores. — The family Mustelidæ, embracing the remaining small carnivores, shows the following features: body somewhat elongated and slender; short legs; small flat elongated head; on each side in upper and lower jaw is a tuberculate molar tooth; glands near the anus that give out a strong odour.

Stoats.—The stoat or ermine (*Putorius erminea*) measures—including the tail—15 or 16 inches in length. In its summer dress it is yellow-brown above and white below; the tail has a black tip. In winter, especially in the north, the colour of the fur is white, save for the tip of the tail, which retains its black colour (the weasel never has the tip of the tail black). The stoat hunts at night, its food consisting of rabbits, hares, rats, mice, birds. There is no doubt, however, that it can do much harm in poultry-yards and among game-birds. In packs, stoats may attack man, and there is a recorded case of a single stoat attacking, at short intervals, a girl and then a man.

Weasel (*Putorius vulgaris*).—This is the smallest of the British Mustelidæ. The length, including the short tail, is about 10 inches. The female is smaller than the male. The elongated body is red-brown above and white below. The slender snake-like body enables the weasel to pass into the holes and runs of mice and rats and voles, all of which are favourite food. The weasel also takes rabbits, young hares, birds building not high up, eggs, and, it may be, poultry. The weasel is a most courageous animal, and, though bloodthirsty and capable of harm, does much good in the destruction of mice and voles. The weasel's nest is in a bank or in a hollow tree; the litter is produced in spring, and numbers 4 to 5 or 6. The weasel, unlike the stoat, does not assume a white coat in the winter time.

Polecat. — The polecat or foumart (*Putorius fœtidus*). Foumart means foul marten, the name being given from the strong scent given off from the anal glands. The colour is chestnut brown-black with yellow soft woolly hairs. The tapering tail is shorter in comparison to the size of the animal than in the case of the stoat, and is bushy. In summer it lives in the open, in hollow trees and in rabbit burrows; in winter the polecat comes nearer to human habitations. The young are produced in summer 4 to 6 at a birth. The food consists of mice, voles, rats, fowls, ducks, game, frogs, eggs. The eggs are sucked without being broken. From its size the polecat is certainly able to do great harm amongst poultry, but this is somewhat atoned for by the destruction of rodents.

The *ferret* is an albino domesticated variety of the polecat.

Badger.—The badger (*Meles taxus*). This is a clumsier and much less active form than any of the preceding. The body is plump and heavy. The head is long, with the muzzle pointed, white in colour, with a broad black stripe on each side. The hair is short and close, and on the back earthy-grey in colour; the belly and feet are black. The tail is short. The badger measures in length 2½ feet

and over. Shy and nocturnal, it lives in a burrow lined with leaves and moss and having long passages leading from it, the openings of which may be far apart. In diet the badger is omnivorous,—roots, bulbs, fruits, acorns, young ground-birds, eggs, mice, rats, young rabbits, insects and their larvæ which are dug up by its sharp broad claws, worms, snails. On the whole, the badger is certainly more useful than harmful, and the animal should not be killed out.

Otter.—The otter (*Lutra vulgaris*) measures 2½ feet in length; the fur is dark brown in colour, and smooth and shining brown. It is well fitted in structure for its aquatic habit. The thick fur with spaces containing entangled air aid in keeping the animal warm; fat glands in the skin keep the skin oiled and so protect it from wet; the flexible body, oiled and slippery, enables the creature to move quickly through the water, while the tail, compressed at the sides, plays the part of a rudder. The toes have swimming membranes on them, and the legs are used as oars; the nostrils can be closed; touch and sight are acute, and the sharp teeth enable it to seize and tear the prey. Otters live in the banks of streams in a chamber, the entrance to which is below the water-level, ventilated by an opening higher up. The food consists of frogs, insects, water-rats, fish. The toll it levies on fish is great.

RODENTS.

These are herbivorous mammals characterised by their incisor teeth being chisel-edged and adapted for cutting or gnawing. The hard enamel of these incisor teeth is typically restricted to the front, and so the hind-part wears away more quickly and leaves the chisel-edge. There are no canine teeth, and the skin projects into the mouth as a hairy pad into the space between the incisors and the cheek teeth. They may be divided into the *Simplicidentata*, where there is a single pair of upper incisor teeth—*e.g.*, rat, mouse, vole, squirrel; and the *Duplicidentata*, with two pairs of incisor teeth in the upper jaw (the extra pair are too small to be of use)—*e.g.*, rabbit and hare.

Rats, Mice, and Voles.

The true rats and mice belong to the family *Muridæ*, and the voles to the family *Arvicolidæ*. These two families may be distinguished as follows:—

Rats and Mice.	*Voles.*
Muzzle pointed.	Muzzle rounded.
Ears large and prominent.	Ears short, almost hidden in the fur.
Tail long, naked, scaly.	Tail short and may be hairy.

The Black Rat (*Mus rattus*).—This rat has long been decreasing before the superior strength of the brown rat, until now it is becoming extinct in Britain. The black rat is smaller and darker than the other. Its food is varied, with a preference for vegetable matter.

The Brown Rat (*Mus decumanus*).—This rat has also such names as the house rat, the Norway rat, the Hanoverian rat, the barn rat. It has a very wide distribution, having been spread over the world in ships. The brown rat has lighter fur than the black rat, and a dusky grey belly; its muzzle is broader, and the ears and tail shorter.

In diet the rat is omnivorous, eating grain of all kinds, peas, beans, potatoes, carrots, turnips, truffles, fruit, the bark of trees, insects, mice, young rabbits, eggs, chickens, pigeons, ducklings, and even one another. In the obtaining of its food the rat often shows great ingenuity. This list of varied foods is one example of how the rat is favoured in the struggle for existence, but there are other factors favouring the rat—namely, its prolific nature,—eight at a litter, and this several times in a year,—and the rapidity with which the rat attains sexual maturity, and the fact that the animal can run, leap, climb, and swim.

One way of fighting rats is by trapping, but in such work one must keep in mind the ingenuity and the cunning of the rat. Another means of destruction is by ferrets. Harvie-Brown recommends, in order to get rid of rats in a poultry-yard, the making of some chloride of lime into a thick paste and smearing the rats' runs with it; or chloride of lime mixed with water in a large watering-can and poured into their holes; or pouring into the holes a strong solution of carbolic acid.

A correspondent of *The Scotsman* recommends the following as a certain way of ridding houses and buildings of rats: "Get from a drysalter a supply of cream caustic soda. It is in a solid state and is cheap. Break the soda up into small pieces; melt some in an iron or stoneware vessel and pour it into the rat holes so that the ground may be saturated with it; then jam one or two pieces into the holes so that the rats may undermine or scrape it away. When the rats come to the mouth of the hole and smell the soda they will begin to scratch under it to remove it; but the fluid soda has wet the soil or stones around and their feet will get blistered, and they cannot remove the solid pieces. Exposure to the air keeps the surface of the soda always damp; but long before all the pieces are entirely melted the rats will have forsaken that hole. As to dogs or poultry suffering by its use, care should be taken to keep them from touching it. Where the ground is undermined by a series of holes, pieces of wood covered by caustic soda should be inserted into the holes and a quantity of melted soda slowly poured on the ground around, giving it time to dry in. Rats are exceedingly cunning, and if they find themselves constantly liable to get severely burned when running about their favourite haunts they will entirely forsake the premises. As to handling caustic soda, it should not be touched with the ungloved hand, and care should be taken in breaking it not to let it spark on the face or eyes."

Very successful results in the war against rats have been got recently from the use of a virus which inoculates the animals, setting up in them a disease which kills them. Of the preparations in the market some are solid and some liquid. The material used contains in it the bacteria or organisms which, introduced into the body of the rat, cause a disease which is allied to typhus fever among human beings. Dry bread is taken, and after being cut into pieces, is soaked with the virus and spread where the rats may find and eat. The virus does not affect any of the domesticated animals. In a case recorded in the *Journal of the Board of Agriculture*, the Agricultural Chamber of Saxony had an experiment on seven selected farms. On six of these the rats were practically exterminated, while on the seventh there was little or no effect, perhaps due to the possibility that the rats on this farm were survivors of the attack of an allied disease and had thereby been rendered immune.

If such experiments be undertaken in Scotland the wisdom of joint action is clear, else a farm rid of the pests by virus treatment might easily receive a new infection from an untreated place. Any treatment, then, with virus should be as the result of organisation and arrangement.

Some of the increase and spread of rats is due to the killing down of such of their natural enemies as owls, kestrels, and weasels.

Mice.

The Common House-mouse (*Mus musculus*).—This mouse is well known; it varies somewhat in colour but typically is grey or grey-brown. Like the rat it is very prolific, and can be a great scourge in wheat-ricks, in corn-fields, and in farm buildings.

The Long-tailed Field-mouse or Wood-mouse (*Mus sylvaticus*). — The burrows of this mouse may be found in banks, in corn-fields, in gardens, and the mouse may also infest stacks. Deserted nests in trees may be made use of for the young. It is a very harmful form, eating grain and all kinds of seeds, beans, peas, fruit, nuts, carrot. This mouse does not go to sleep for the winter, but lives off stores of varying food materials—*e.g.*, it may store great quantities of grain. The wood-mouse is yellowish brown, with a greyish tinge on the back, while below it is white; the breast is white, with a dark or fawn patch; feet white; the tail is brown on the upper surface and white on the under.

Here is a table quoted in *The Zoologist* for April 1881 to show how prolific the wood-mouse is:—

					Interval since last litter.
March	7 or 8.	A	3	young . .	...
"	19.	B	5	" . .	...
"	31.	A	3	" .	24 days.
April	18.	B	5	" . .	29 "
"	24.	A	3	" . .	24 "
May	11.	B	5	" . .	23 "
"	17.	A	4	" . .	23 "
June	12.	A ?	4	" . .	26 "
July	9.	A ?	4	" . .	27 "

This mouse does some good by feeding on insects, moths and their larvæ, and beetles. The mouse itself is dug out and eaten by crows and rooks, and foxes also hunt for them.

The Harvest-mouse (*Mus messorius* or *minutus*).—This is the smallest member of the family, and, save for the lesser shrew-mouse, is the smallest British quadruped. It measures 2½ inches. It lives in stacks and in the open. In colour this mouse is red-brown or sandy-yellow, with the belly white. In climbing among grasses and shrubs it makes use of its prehensile tail. It builds a neat nest of dry grasses twined cleverly round the stems of the plants. The food consists of grain and insects.

Voles.

The Water-rat or Water-vole (*Microtus* or *Arvicola amphibius*).—This vole is 6 inches in length. It is dark-brown or black above, and grey to greyish-black or brown below. The cusps on the back teeth are angular, whereas in the true rat they are rounded. Commonly found along the banks of streams, it also burrows in meadows and fields at some distance from the water. The passages it makes in the river-banks and in canal-banks may cause the destruction of the banks. This vole is a good diver and swimmer. Its chief food is of vegetable nature,—aquatic plants, roots like turnip, carrot, and mangel, and the bark of root and stem of shrubs and trees, osier beds for example being sometimes much harmed.

The Short-tailed Field-vole (*Microtus agrestis*).—This (fig. 630) is one of the greatest enemies in pasture and other land. The back is dark-brown and the under surface grey. It has great powers

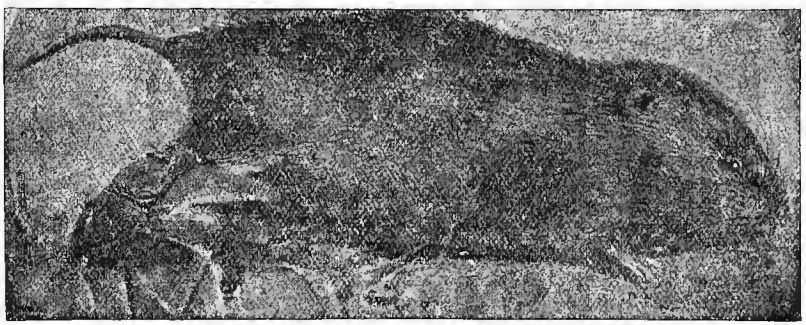


Fig. 630.—*The field-vole.*

of multiplication. The field-vole is found not only at low levels but in upland and hill pastures, and there are records both in Scotland and elsewhere of plagues of this species. In 1890 these voles had been noticed to increase, and in 1891 the hill pastures of Roxburgh and Dumfries were overrun with their burrows, and 90,000 acres of land were more or less affected. In addition to the loss entailed by this pest on the farmer, the forester may also suffer severely, both young broad-leaved species and conifers having their roots gnawed through, or being stripped of their side-shoots, or being barked. In 1814 practically all the oak saplings in the Forest of Dean were destroyed owing to their roots being eaten through by this species. Of the field-vole and the wood-mouse in this plague of 1814, no fewer than 100,000 tails were brought in for reward. This vole nests below ground, there being several litters, especially in the warmer part of the year, four to five or more in a litter; but breeding may take place from the spring to the late autumn.

The Bank-vole (*Evotomys glareolus*) is also harmful in field and forest, the edges of woods and sheltered banks being characteristic places for it. In length it measures up to 4 inches; the colour is red or red-brown above and white below; the feet are also white. The tail is more hairy and the ears are larger than in the last species. It is harmful to trees,

gnawing various broad-leaved and conifer species, and eating also the buds of the pine.

Measures against Mice and Voles.

The turning out of cats has been tried. The ground, too, should be cleared, so as to better expose the pests to their natural enemies—*e.g.*, owls and kestrels; the weasel is worthy of mention, too, though it has been admitted as possibly harmful in another connection. The grazing of cattle keeps down the undergrowth, and so prevents shelter and destroys breeding-places. Several times in Scotland and England, in bad infestations, much good has resulted from digging trenches 30 yards apart, 18 to 20 inches broad at the bottom, 9 inches broad at the top, 1½ foot deep, and 2 feet long: mice and voles falling in were unable to climb the inward-sloping sides, and so were trapped. In a devastation at the Forest of Dean 30,000 field-voles were caught by this means.

Injury to trees can be prevented by smearing them with asphalt-tar or one of the patent tars. A further method of preventing injury consists in spreading here and there, beside the young trees to be protected, a few branches of soft-wooded trees. These are used as food, the voles preferring to bark or nibble what is lying on the ground rather than the trees. These branches should be changed at intervals, for as soon as they are dry the rodents will cease to use them for food but will utilise them for shelter. Should poison be resorted to, such collections of branches would be good positions in which to place the bait. In poisoning, the oatmeal or flour mixed with arsenic or other poison should not be left exposed, but should be placed in glazed pipes 1·½ inch in diameter: the mice then get access to the bait, while larger animals cannot reach the poison.

Hares and Rabbits.

The Rabbit (*Lepus cuniculus*) and the **Hare** (*Lepus timidus*) can be harmful both in agriculture and in forestry. They eat such plants as young grass, cabbages, turnips, vetches, carrots, grain, and the bark of a large number of species of trees. Not only does the rabbit multiply more quickly than the hare — 5 or 6 litters in a year, with 4 to 6 young at a time, and reproduction capable at 6 months old — but its burrowing habit makes it more difficult to keep down. Shooting, fencing with wire, netting, ferreting, are the measures practised against these animals.

The Squirrel.

The Squirrel (*Sciurus vulgaris*) has relation more to the forester than the agriculturist. While the squirrel by its grace and liveliness is an ornament to our woods, if the numbers be great immense damage can be done. Its chief food consists of acorns, beech-nuts, hazel-nuts, and the seeds of conifers. Buds of trees and young shoots are destroyed, and the bark of pine and larch and other trees is stripped or gnawed off in large patches. Insects may be taken, and sometimes eggs and young birds.

INSECTIVORA.

These are small plantigrade mammals with five strongly-clawed toes. The teeth vary, but the molars have pointed prominences on them. The nose is sensitive, being prolonged into a proboscis, useful as a tactile organ. Examples are the hedgehog, mole, shrew.

The Hedgehog.

The Hedgehog (*Erinaceus europæus*), while not fitted in structure for a burrowing habit, has managed to survive in the struggle for existence, to a great extent by means of its protective spiny-armour and the resemblance of its colour to its surroundings; it is also nocturnal in habit. It hides in the day-time in its dwelling by ditch or hedge sides, and under bushes or brushwood, or in hollow trees. It has a varied bill of fare—slugs, snails, insects, worms, mice and voles, frogs, snakes, eggs of game-birds and poultry, chickens and ducklings. Fruit in the shape of windfalls may be taken.

The Mole.

The Mole (*Talpa europæa*) is specially fitted by its structure for a life in the earth. The fore-limbs are excellently fitted for digging and throwing aside the soil; they are short and broad, and have strong claws, and are worked by powerful

muscles; the collar-bones are strong and give attachment to the fore-limbs; the wedge-shaped head and round body aid in the movement through the soil; the hind-limbs are used in propelling the animal; powerful muscles give such strength that the mole can bury itself very quickly in a firm soil; there is no flap-like external ear to get filled with earth; the nostrils by being directed downwards do not get choked up with sand or fine soil; the mouth can be closed tight by a skin-fold on the upper lip; the fur standing erect and always smooth does not interfere with a backward movement should this be necessary; while the shortness and closeness of it keep out water and dirt; the sharp canine teeth and the projecting tubercles on the molars are fitted for seizing, holding, and crushing the prey.

The most acute senses are smell and touch. Eyes are present, small and bead-like, and buried in the fur; they are not of service underground but are of use when the mole comes to the surface.

The mole-hills (fig. 631), which are formed of soil thrown up from shafts leading from the runs, must not be mistaken for the nest. The nest of the mole is under a heap of earth larger than the ordinary mole-hill; it is lined with vegetable matter, such as leaves, dry grass, or moss, and consists of a central chamber

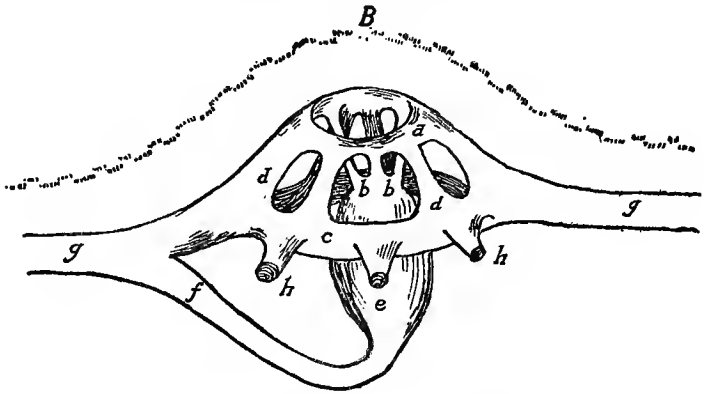


Fig. 631.—*Mole-heap.* (Schlich and Fisher.)

B, Surface of ground.
a, Upper gallery.
b, Descending passages.
c, Lower gallery.
d, Ascending passages.
e, Central chamber.
f, Passage to chamber.
g, Moles' run.
h, Diverging runs from lower gallery.

with passages varying in position; the passages are in association with the runs. The depth of the runs varies with the weather and with the season.

The young are born in May, two to six being a litter (the female has six teats). They are born blind and naked, and begin to run about in five weeks or so.

The food of the mole consists chiefly of insect larvæ and earth-worms, and its appetite is voracious; slugs are also eaten. In a nursery or a garden a mole may be a nuisance by throwing up the heaps of soil, so also in a pasture; the mole-hills, too, interfere with the mowing of the grass, and later with the cutting of the corn, but it should be remembered that the diet can be mainly an insectivorous one.

Owls, buzzards, and the weasel are natural enemies of the mole. The animal, if too numerous, can be kept down by trapping; and in a garden it is said to be kept off by putting in thorns, these injuring the sensitive snout of the mole.

The Shrew.

The Shrew-mice are small insectivores with soft fur, a somewhat pointed snout, external ears, and hairy tails. There are three British species.

The Common Shrew (*Sorex vulgaris*) lives in runs below the soil but near the surface. The fur is velvet-like, the eyes are small, and the proboscis is sensitive.

The colour is reddish or brown-black above and grey below. Like other species, it gives off a strong musk-like odour, which may serve as a protection against enemies, but Harting has found numerous skulls of shrews in the "castings" of the barn-owl, and once found two little shrews in the stomach of a curlew. The shrew feeds on insects, worms, slugs.

The Water Shrew (*Sorex fodiens*), a larger species, black above and white below, and measuring up to 3½ inches, feeds on insects, including the aquatic caddis grubs, and on fresh-water molluscs and crustacea: it is said to eat the fry of fish. This shrew swims well, long hairs on the hind-feet being spread out when swimming, and acting as oars

The Lesser Shrew (*Sorex pygmæus* or *minutus*), about 2 inches long, is the smallest British mammal. It feeds on insects.

In spite of several unkind superstitions, shrews are practically harmless animals.

BIRDS IN RELATION TO THE FARM.

Many birds are of economic importance to the farmer, the gardener, and the fruit-grower: some because they are distinctly harmful to crop plants and their seeds; some because they are useful, inasmuch as a great part of their food consists of injurious insects; and still others, with a mixed diet, whose position as useful or harmful cannot be stated with definite certainty. Part of the difficulty in deciding into which set, economically, a bird must be put consists in the absence of organised investigation, and of direct examination, of the contents of the crops and stomachs of shot birds. Such an examination, too, should extend over all months of the year where the species is a resident one. There is the further difficulty that there may be a certain adaptability on the part of birds to the different kinds of food material available in different districts, and therefore, as the result of inquiries in a single district only, too sweeping generalisation as to food taken may be fallacious.

The most important birds in relation to the farm are briefly reviewed here.

BIRDS OF PREY.

The Kestrel (*Falco tinnunculus*).—This bird may be recognised from its habit of hovering motionless for long periods in the air, hence one of its names, the "Windhover." In colour it is reddish-brown, the male having dark spots on the back, and the female dark bars; the under parts are buff, streaked and spotted with black; the legs and the feet are yellow; the beak is blue, but the cere at the base of the bill is yellow. The length is 14 inches. Although the kestrel has been blamed for taking game birds, the consensus of opinion is certainly in favour of the usefulness of this bird. Its food consists, to a very great extent, of mice and voles; insects are also taken. On the Continent it is regarded as most useful to the cultivator.

The Sparrow-hawk (*Accipiter nisus*).—From the farmer's standpoint the sparrow-hawk is useful and not harmful. It is chiefly a bird of the woodlands. Its food consists of small birds and game birds, and also poultry; it is an enemy of the wood-pigeon. Insects also, and some of them very injurious, are taken. It has not the long wings of the kestrel, and the wings are rounded; it is thus not a very quick flier in a long chase, hence its cunning when hunting for prey.

The Barn Owl (*Strix flammea*).—This owl, known by its white breast and buff-coloured upper parts, is also called the White and the Screech Owl. In spite of the way it has been persecuted, it is a most useful bird. Like other birds of prey, the barn owl has the habit of disgorging, by way of the mouth, indigestible particles in the form of pellets. Dissection and examination of great numbers of these by competent and unprejudiced observers has proved that fur and not feather is the chief food. Seebohm states that in 700 pellets from this owl,

there were found the remains of 16 bats, 2513 mice, 1 mole, and 22 birds of which 19 were sparrows. Mr J. E. Adams, in 1124 pellets examined by him, found the remains of 2397 mice and rats and 97 sparrows. This owl, along with the brown owl and the short-eared owl, have proved useful enemies of the voles in the plagues on hill farms.

The Brown or Tawny Owl (*Syrnium aluco*).—This owl has the upper parts ash-grey, mottled with brown; the wing-covert feathers have large white spots at their outer webs; the tail is tipped with white; the under parts yellowish-white, and mottled with brown. The male measures 15 inches in length; the female is larger, and often more red-brown. From its note this owl is called the "hooter." It is, like the last, a useful bird; its food consists of rats, mice, voles, small birds, *e.g.*, finches, and injurious insects.

The Long-eared Owl (*Asio otus*) and the **Short-eared Owl** (*Asio accipitrinus*).—These should also receive protection, their food being chiefly rats, mice, and voles. The short-eared owl is typically a winter visitor with us, leaving in spring; but in the vole plague of 1892-93, in the south of Scotland, food, in the shape of voles, was so abundant that the short-eared owls stayed, and bred and reared more than one brood. Some fifty or more pairs could have been counted on a single farm. This owl has a somewhat hawk-like appearance as seen by daylight on a dull day—for it hunts by day as well as in the evening. The long-eared owl is resident in wooded parts of Britain all the year round, the residents having their numbers added to in autumn by migrants.

The Crow Family (Corvidæ).

In the family we have the raven (*Corvus corax*), hooded crow or hoodie (*C. cornix*), carrion crow (*C. corone*), rook (*C. frugilegus*), jackdaw (*C. monedula*), chough (*Pyrrhocorax graculus*), magpie (*Pica caudata*), and the jay (*Garrulus glandarius*).

Raven.—The raven is the largest of the family, and is black, with a purple-blue sheen on the upper parts. It is omnivorous in diet, and is looked upon as an enemy by sheep-farmers, where the bird is found.

The Hooded Crow is recognisable by its ash-grey back, the head, throat, wings, tail, and thighs being black; there are varieties.

The Carrion Crow is entirely black, the male being glossier than the female; this crow is distinguished from the rook by the presence of a tuft of feathers at the base of the bill, instead of the grey patch; it has also a harsher cry, and in habit is not gregarious. In food habits the carrion crow and the hoodie practically agree: carrion, eggs of game and other birds, poultry, moles, rats, fish, insects and their grubs. Weakly ewes and lambs may be attacked.

Rook.—The rook—or the crow as it is called in Scotland—is black, with a grey warty patch at the base of the bill. Concerning this bird there is always great controversy. There is no doubt that it does much harm, but one must hurry to add that it also does good. Many people, with regard to the rook, find it difficult to say guilty or not guilty, and fall back on the Scottish verdict of not proven. Sir John Gilmour's[1] verdict, as a result of his investigation with rooks shot from January to December, and dissected for determination of the food contents, is that this bird is "a cunning rogue." Of 355 rooks shot, 336 had food contents. Of the contents, 58 per cent consisted of the grains of wheat, barley, oat, and rye; 23 per cent of insects and grubs, 12 per cent miscellaneous, 7 per cent roots (potatoes), no leaves, flowers, fruit, or seed being found. Dr Hollrung of Halle has given, in a German agricultural journal,[2] the result of post-mortem examinations made on 4030 rooks, over a period of years from 1895-1905. In this report there appears—

GRAIN, &c., TAKEN BY 4030 ROOKS.

	Grains.		Grains.
Sprouted—		*Sprouted*—	
Wheat .	15,578	Potatoes .	587
Barley .	10,465	*Unsprouted*—	
Oats .	12,787	Barley .	247
Maize .	987	Maize .	40
Buckwheat	1,777	Rye .	358

[1] *Transactions of Highland and Agricultural Society*, 1896.

[2] *Landwirtschaftliche Jahrbucher*, 1906.

INSECTS TAKEN BY 4030 ROOKS.

Cockchafer beetles	2,222
,, grubs	2,264
Click beetles	2,307
Wireworms	1,589
Weevils	14,710
Caterpillars	9,126
Leather-jackets	3,411
Tortoise beetle	2,062
Leaf beetles	2,133
Garden-chafer and other small chafers	1,717
Burying beetles	984
Maggots of Bibio flies	406
Corn Ground-beetle	86

Mr Cecil Hooper,[1] writing from south-east England, points out that rooks damage fruit, eating "green strawberries, cherries, gooseberries, especially in dry weather, and sometimes apples and pears; it dearly loves walnuts, also cob and filbert nuts." As to the fruit-eating habit, Phil Robinson has written: "The poor farmer never suspected the rooks to have eaten his cherries. No one did. They said it was the blackbirds, and the thrushes, and the sparrows, and those boys of Chinnery's. So they caught blackbirds in traps, and harried the sparrows' nests, and had a row with the Chinnerys. And yet is it not written in every book that the rook is *Corvus frugilegus*, the fruit-eating crow?" As far back as the time of Henry VIII. we find enactments against the rooks as destructive to corn and grain, thus, that "every one should do his best to destroy rooks, crows, and choughs, upon pain of amercement, and that every hamlet should provide and maintain crow-nets for ten years, and that the taker of the crows should have after the rate of 2d. per dozen."

On the other hand, the rook's insect-eating habit must be stated. In Sir John Gilmour's investigation the insects found in the rook were wireworms, leather-jackets, turnip-moth caterpillars, and a number of ground-beetles, adult and larva. Most of the ground-beetles are predaceous and useful. Rooks certainly are of service in the destruction of the leather-jackets' or daddy-long-legs' larvæ and of wireworms; we have found them gorging themselves on the grubs of the garden-chafer in a hill pasture; they take winter-moth caterpillars, and have been serviceable in destroying the caterpillars of the green tortrix moth of the oak.

It cannot be denied that farmers may suffer much loss from rooks. Hollrung, whose tables were quoted above, concludes from his examinations that while the extermination of rooks is under no circumstances justifiable, it being clearly proved that they destroy harmful insects, some of which are with difficulty reached by artificial means, yet in the neighbourhood of rookeries the harm done easily outweighs the good, and that where rooks occur in large flocks excess of damage is to be feared, especially at times of the year when insects are scarce: where rooks are few in number or widely dispersed, and where harmful insects abound, rooks are undoubtedly useful.

The Highland and Agricultural Society has issued warnings, and the Board of Agriculture has suggested ways in which rooks in arable districts might be kept down. Several methods have been quoted by the Board in its *Journal*.[2] Thus a plan reported from Scotland as adopted with success: "A frosty night was selected, just after the rooks had laid their eggs, but before they were sitting closely, and a man was placed, with a gun, in every clump of trees where the rooks were for an area extending over two or three miles of country. At a fixed time shooting was begun, not so much with the idea of killing the birds, but more particularly for the purpose of keeping them off the nests. Firing was kept up for about three hours from just before dusk, with the result that the eggs were frosted and became infertile. This has now been done regularly for four years, with the result that the rooks are considered to have decreased by 80 per cent, and their numbers are now within limits."

Another method practised to keep the numbers in control is to shoot the young birds. Mr H. W. Slater[3] says: "My own practice is to kill two young birds to each nest, and to leave the rest, which appears just enough to counterbalance the waste of accident and old age."

[1] *Journal of Society of Arts*, vol. iv., Dec. 14, 1906.

[2] *Journal of Board of Agriculture*, July 1906.

[3] *Journal of the Farmers' Club*, April 1895.

Two mixtures[1] have been given for protection of seed against rooks—2½ oz. of coal tar, 2½ oz. of petroleum, 1 quart of water; this suffices to dress a bushel of seed. And again, 11½ pints of coal tar, 5¾ pints of petroleum, 1 11/12 pints of carbolic acid to 5 quarters of seed. The instructions given are: "The proportions named should be strictly adhered to in order to obtain successful results. Commercial carbolic acid of full strength must be used. The mixture should be made as follows: place the coal tar in a pot on a slow fire until it is quite hot and shows signs of boiling, remove it from the fire and add the petroleum while stirring, and finally the carbolic acid. The mixture should be thoroughly well stirred, and it will remain quite liquid after cooling.

"In order to treat the grain, about 4 bushels of seed should be spread out on a water-tight floor, and a tenth part of the mixture, which will be a little less than 2 pints, poured on it. This must then be stirred up quickly until each grain is blackened, and the whole is about the colour of roasted coffee. The seed, however, cannot be sown in this condition, as it would stick to the cups of the drill, and in order to dry the seed add afterwards to each 4 bushels of seed about 2 pints of phosphate of lime. When mixed the grain will be quite dry, and can be sown in the ordinary way. Seed treated in this way will not be touched by crows, though the growth may be retarded by some two or three days. The cost per bushel is insignificant."

Jackdaw.—Has rounded wings and grey nape; it is generally distributed. It is an egg stealer, and kills young birds, and does some harm to cherries, but it takes insects and their larvæ, and also keds from the sheep.

Chough.—A bird of the west coast and islands. A little bigger than a jackdaw, it is black in colour, with the bill, legs, and feet red.

Magpie.—This handsome bird has head, neck, back, and breast black, glossed with green; belly and scapulars white; the secondary feathers are black, the primary feathers black, with white on their inner parts; the tail is black and has a greenish-bronze sheen. In diet it is omnivorous—insects, slugs, mice, birds, and eggs.

Jay.—This is a bird of the woods, a beautiful bird with a crest of white, tipped with black; nape and back light brown; the rump white; tail black; the wing coverts barred with black, white, and blue.

Pigeons.

Wood-pigeon, or Cushat, or Ring-dove (from the white feathers that encircle the neck) (*Columba palumbus*).—A resident in Britain, and generally distributed in wooded districts. It is increasing in numbers; the native wood-pigeons are added to in winter by great numbers which arrive on the east coast from the Continent. Two or three broods are reared annually. By common consent this bird is one of the great farm enemies. In many places—*e.g.*, the north-east of Scotland—the wood-pigeon is proving at present a very severe enemy of the farmer. Its powers of destruction may be estimated by the wholesale levy it makes on the products of the fields and of the woods, as thus enumerated by Macgillivray:[2] From its roost in the larger branches of trees "it issues at sunrise to search the open fields for its food, which consists of seeds of the cultivated cereal grasses—wheat, barley, and oats; as well as of leguminous plants—beans and peas, and of the field-mustard and charlock. In spring it also feeds on the leaves of the turnips and picks the young blades of the red and white clovers. At this season I have several times found its crop distended with the farinaceous roots of *Potentilla anserina*, obtained in the ploughed fields. This root is highly nutritious, and formerly, in seasons of scarcity, was collected in the West Highlands and Hebrides as an article of food, and eaten either boiled or roasted in the peat-ashes (the plant is a troublesome weed). In summer the wood-pigeons eat grass and other vegetable substances; in autumn grain, beech-mast, acorns, and leguminous seeds. The beech-masts and acorns they swallow entire, their bill not

[1] *Journal of Board of Agriculture*, December 1904.

[2] Macgillivray's *Brit. Birds*, i. 115, 263.

being sufficiently strong to break them up."

The wood-pigeon destroys the growing crop in the manner described by an eye-witness watching near:[1] "The wood-pigeon has a weak bill, but nature has provided her with very strong wings. When the flock, therefore, settle upon the lying portion of a wheat-field, instead of breaking off the heads and carrying them away, they lay themselves down upon their breasts upon the grain, and, using their wings as flails, they beat out the pickles from the heads, and then proceed to eat them. The consequence is, that the pickles having been thrashed out upon a matting of straw, a great proportion of them fall down through it to the ground, and are lost even to the wood-pigeon; in short, they do not eat one pickle for twenty which they thrash from the stalk. I have repeatedly watched this process from behind the trunk of a large willow-tree, growing in a thick-set hedge on the edge of a wheatfield, and seen the operation go on within two yards of me. The pigeons descend first singly; but, having left a watcher upon the highest tree in the neighbourhood, the whole flock are soon at work on the same spot, and the loss of corn to the farmer is very great. They are also gluttons in quantity."

Sir John Gilmour, in the report of the investigation referred to above, gives a post-mortem record of what MacAlpine found in the case of 245 cushats shot from January till December. The record is a most interesting one, showing, alongside of the heavy toll levied on the farmers' crops, the weeds which are also taken as food.

Kinds of Food.	Crops.	Weeds.
Cereal grains.	Barley.	
	Oat.	
	Wheat.	
	Rye.	
Leaves.	Red clover.	Charlock.
	White clover.	Runch.
	Alsike clover.	Creeping buttercup.
	Turnips.	Oak.
	Swedes.	
Fruits and seeds other than cereals.	Beans.	Charlock.
	Peas.	Runch.
	Tares.	Goose-grass.
	Clovers.	Spurrey.
	Turnips.	Mouse-ear chickweed.
	Swedes.	Common chickweed.
	Rye-grass.	Field speedwells.
	Seeds of mixtures.	Docks.
	Maize (from artificial foods).	
	Elm fruits.	
	Beech-nuts.	
	Wild cherries.	
	Haws.	
Roots and underground stems.	Turnips.	
	Swedes.	Lesser celandine.
	Potatoes.	
Flowers.	Beech.	Charlock.
	Elm.	Creeping buttercup.
		Annual meadow-grass.

A few earthworms were taken for the young birds. It is pointed out by Gilmour that it is the best of the crops which are attacked — the grains of cereals, the leaves of clovers and turnips, the seeds of beans, peas, &c.

That cereal grains and leaves are the foods freely used by wood-pigeons is seen from this additional table:—

Kinds of food.	Number of times taken during the year.	Per cent.
Cereal grains . .	123	33
Leaves	103	27.5
Other fruits and seeds	88	23
Roots . . .	31	8.5
Flowers . . .	29	8

[1] Burn Murdoch's *Observations on Game*, p. 11.

The crop or store-chamber of the pigeon is large, and T. H. Nelson[1] gives various records to show its capacity—viz., a cupful of turnip tops (December 1884); 61 acorns in another; 76 acorns and a quantity of swede tops (18th December 1883); 73 hazel-nuts (January 1884); another containing 838 grains of corn.

The task of fighting the wood-pigeon is rendered difficult by the bird's wariness, while its nesting habits do not bring the bird into the farmer's power in the way that the habits of the crow or rook do.

Stock-dove.—The Stock-dove (*Columba œnas*) can be told from the wood-pigeon by its being smaller and by the absence of the white feathers on the sides of the neck. This bird has been increasing of late years in England, and in some parts of the north of Scotland is now fairly plentiful. In food habits it resembles the wood-pigeon.

The Starling (Sturnus vulgaris).

This is a common resident in Britain, where it has increased enormously in late years. Additional hosts of migrants add to the native starling population in autumn and winter. Its long strong legs with their blunt nails fit it for running rapidly about for hours. Its long beak helps the bird in its careful search of grass-tuft and crevice. It is, from the standpoint of the farmer, a most useful bird. Insects form the great bulk of its food, wireworms, leather-jackets, caterpillars of grass-moth, surface caterpillars, diamond-back moth, &c. Further, the starlings perch on the backs of sheep and help to clean off the keds, although it has been stated that the excrement of the starling attracts the sheep-maggot flies. The fruit-grower, however, looks upon the starling as levying too severe a toll upon fruit, cherries, raspberries, strawberries, damsons, plums, pears, apples. Two broods may be reared in a year; the birds are hardy and able to hold their own.

In the investigation conducted by Gilmour, the starling was included.[2] The number of starlings shot from January to December, in which post-mortem examinations were made, was 175. As a result, it is concluded that while the starling can take and use many and varied articles of food, the range of staple food-stuffs is very narrow. Three-fourths of starling food was found to be insect, and one-fifth grain. The general estimate based on the above examinations is, that the "starling is a bird to be fostered rather than destroyed, a benefactor rather than a foe." The table added indicates the relative importance of the foods:—

Food-crop.	Number of times taken during the year.		Per cent.
Grub	30	182	70
Adult insect	152		
Grain	58		22
Miscellaneous	21		8
Roots	0		0

Of the insects found, there were rove-beetles and some ground-beetles, both useful in agriculture; and of injurious insects, Pterostichus (a ground-beetle injurious to strawberries); adult click-beetles, and weevils, and the larvæ of click beetles (wireworms), daddy-long-legs (leather-jackets), the grass-moth, and a species of Hepialus.

Thrush Family (Turdidæ).

Of this family may be mentioned the song-thrush, the missel-thrush, and the blackbird.

Song-thrush (*Turdus musicus*) **or Mavis or Throstle.**—The mavis is a resident in Britain, the places of those which migrate in the autumn being taken by others from the Continent. The food consists of insects, slugs, snails, fruits. As to fruit, it can be extremely troublesome. This bird rears two or three broods in a season.

Missel-thrush (*Turdus viscivorus*).—This is the largest of the British thrushes, and is also a resident. From its singing out defiance to the storm it is known as the storm-cock. Its food consists of the berries of such plants as holly and mountain ash, fruits, snails, worms, insects. In the south it is very destructive to fruit. The bird is rather a bully, charging away and scattering smaller birds.

Blackbird (*Turdus merula*).—This

[1] *Ornithology in Relation to Agriculture and Horticulture*, p. 90.

[2] In connection with these post-mortem examinations of rooks, wood-pigeons, and starlings, the birds were shot on Sir John Gilmour's estates in Fifeshire.

bird is also a resident—*i.e.*, Britain is not without blackbirds at any time of the year; the places of such as fly south in autumn are taken by numerous winter visitors. The male is black, with the beak yellow; the female black-brown, and the bill is brown. There are several broods in the year. The food consists of fruit, insects and their larvæ, worms. It is looked upon by fruit-growers as a great scourge.

For keeping off the blackbird and thrush from fruit it is suggested in Bulletin No. 11 of the Yorkshire College, Leeds, that an effective method is "to attach a cat by a ring and swivel to a long cord fastened securely at each end, so that the cat can walk up and down the length of its tether."

Swallows and Martins (Hirudinidæ).

The Swallow (*Hirundo rustica*), the **House-martin** (*Chelidon urbica*), and the **Sand-martin** (*Hirundo riparia*) are entirely useful birds, their diet being an insectivorous one, and the fact that these birds are decreasing in numbers is a loss to the agriculturist. The birds are often confused; they may be distinguished thus—

Swallow.	Martin.
Forehead and throat chestnut brown.	
Upper surface steel blue, including the rump.	Upper surface steel blue, except the rump, which is white.
Lower surface dusky reddish white (the female has the lower surface white).	Lower surface white.
Tail markedly forked (the female has the outer feathers of the tail shorter).	Tail not markedly forked, and the wings shorter. Feathers on feet and toes.
Eggs white, but speckled with brown or dark red spots.	Eggs pure white.
Nest open at the top.	Nest with a small hole only for entrance.

The sand-martin is smaller than either of these two birds, and its upper surface is brown or mouse-coloured. It nests in steep river-banks, sand-pits, gravel quarries, and railway cuttings, the tunnels made by the birds being from 18 inches to 6 feet in length, with the nest in a chamber at the end.

The Spotted Fly-Catcher (Muscicapa grisola).

The Fly-Catcher comes to Britain in April, leaving again for the South in autumn. It is rare in Scotland. Saunders[1] describes this bird thus:—

"The adult has the crown light brown, with dark streaks down the centre of the feathers; upper parts hair-brown, slightly darker on the wings and tail, and paler on the margins of the wing-covers; chin and under parts dull white, with brown streaks on throat, breast, and flanks. Length, 5.8 inches. The young are very much spotted."

The bird is entirely useful, being insectivorous in diet; all kinds of insects are taken.

[1] *Manual of British Birds.* By Howard Saunders. P. 158.

The Water-Wagtails (Motacillidæ).

There are five British species, of which the three commonest are the pied wagtail (*Motacilla lugubris*), the grey wagtail (*M. melanope*), and the yellow wagtail (*M. campestris*). All the wagtails deserve protection, as they are entirely useful. They feed greedily on insects and small molluscs.

The Titmice (Paridæ).

This is another useful family. Perhaps the most useful of all the tits is the blue tit (*Parus cæruleus*), a bird about 4½ inches long, and with blue, yellow, and green coloured plumage. Insects are its chief food, but Mr Hooper accuses it of sometimes "doing serious damage by pecking cherries and the sweeter-flavoured apples and pears."

The Great Tit. — The great tit, or tomtit (*Parus major*), known also as the ox-eye, is a resident species. In length it measures about 6 inches. The upper side is yellow-green, the under surface light yellow; the top of the head, the throat, and a stripe on the breast are black; under each eye is a white patch. The legs are short and strong, and have curved claws

that fit the bird for climbing and clinging. The short conical beak is well fitted for picking up insects and their eggs. Besides destroying the eggs of numerous harmful moths and insects, it takes seeds, beechmast, and nuts; like the blue tit it pecks holes in apples and pears. The blue tit and the great tit destroy bees. The planting of sunflowers—of the seed of which these two tits are fond—lures them away from the fruit.

Buntings (Emberizinæ).

Yellowhammer. — The yellowhammer (*Emberiza citrinella*) is a common resident in Britain; there are two broods in the year. It takes insects, but prefers for its own eating corn and seeds, particularly oats; and in new-sown fields of oats, as well as wheat, it may be seen busily picking up the grain from the moment it is sown to the period of its brairding; the seed of such weeds as plantain, dock, thistle, chickweed, and pod-grass are taken. By autumn, when the broods are reared and the corn crops begin to ripen, the yellowhammers assemble with sparrows and corn-buntings, and leave little alongside the hedges but empty husks on the standing straw. When feeding in the stubble-fields, they advance by short leaps, with their breasts near the ground; when danger approaches they crouch down motionless; and when alarmed, give out their ordinary short note, *yite, yite.* They are more shy than chaffinches, but less so than the corn-buntings.

Reed-Bunting.—The reed-bunting, or black-bonnet (*Emberiza schœniculus*), lives mostly on weed seeds, though small patches of oats on the crofts in the upland districts attract its notice. It also takes insects and their larvæ. Not being shy, it is not easily scared away. It is a British resident, but may be migratory in parts of Scotland, departing in October, and reappearing in the beginning of April.

Corn-bunting.—The corn-bunting (*Emberiza miliaria*) feeds on corn, and in spring, together with the yellowhammer and others, devours considerable quantities of seed-corn of oats and barley. After the breeding season it feeds on beans, peas, wheat, oats, or barley, while during autumn it feeds on the stubble-lands, sits close, and is shy. It visits the new-sown fallow and potato-wheat. In winter it is remarkably fat, and superior as an article of food to most of our small birds.

"It could hardly be supposed," observes Knapp, "that this bird, not larger than a lark, is capable of doing serious injury; yet I this morning witnessed a rick of barley, standing in a detached field, entirely stripped of its thatching, which this bunting effected by seizing the end of the straw, and deliberately drawing it out to search for any grain the ear might yet contain—the base of the rick being entirely surrounded by the straw, one end resting on the ground, and the other against the snow, as it slid down from the summit, and regularly placed as if by the hand; and so completely was the thatching pulled off, that the immediate removal of the corn became necessary. The sparrow and other birds burrow into the stack, and pilfer the corn, but the deliberate operation of unroofing the edifice appears to be the habit of the bunting alone."

The Finches (Fringillinæ).

The Chaffinch (*Fringilla cœlebs*), or **Shilfa,** is a generally distributed species in Britain in cultivated and wooded parts. The male is a handsome bird: forehead black, back of neck slate-blue, back brown, rump greenish, the breast reddish-pink, wings black, with a white and a yellow transverse band. The female is duller. A beautiful nest is made of moss, wool, and lichens felted together and lined with hair and feathers. Two broods are generally reared in a year. After the breeding season they collect in flocks, roving about, males and females separately. There is a migration southward at the end of the autumn, but one can always find examples, males chiefly, in the winter time. The chaffinch takes insect food, especially at the breeding season, but its diet to a great extent consists of seeds, coniferous seed, beech-mast, groundsel, chickweed, charlock, knot-grass. The short, thick, conical beak, with sharp edges, is well suited for removing the husks of seeds. On recently-sown beds it is troublesome, taking out the sprouting carrot, lettuce, radish, cabbage, turnip, onion. It is

also a disbudder of gooseberries, currants, and plums.

The Greenfinch or Green Linnet (*Ligurinus chloris*).—Like the last, it is a resident in cultivated and wooded districts. Yellowish-green is the prevailing colour. There is a golden-yellow stripe over each eye; bill dull flesh colour. Two broods are often reared in a season. It takes some insect food, but in the seed season, accompanied by the young brood, will attack almost every sort of seed that is ripe or ripening—*e.g.*, turnip, mustard, sainfoin; oat-fields and even wheat-fields near woods and hedges may suffer considerably; the seeds of weed plants are also taken; it pulls hop flowers to pieces, and may do the same to fruit blossom. Where present in numbers, its seed-eating propensity renders it capable of considerable harm.

Linnet.—The grey or brown linnet (rose lintie) (*Linota cannabina*) does more damage than is generally supposed. It visits patches of turnips left for seed, and frequents the newly sown turnip-fields. When the young families begin to wander in small companies as the corn becomes ripe, they devour large quantities of the standing corn, voraciously living upon it from the moment it begins to whiten until led to the stackyard. After this period the smaller families associate in larger flocks, frequently combining with the greenfinch, and subsist on the stubbles. It frequents newly sown wheat-fields, and thins the seed-corn in detached patches so much, that the scantiness of the braird is ascribed to the attacks of a grub. It is easily scared. There is a marked seasonal change of plumage. In spring and summer the feathers of the head and breast are red-brown tipped with bright red, but on the approach of winter the latter tint almost wholly disappears.

Goldfinch.—The goldfinch (*Carduelis carduelis*), local and rarer in Scotland, is generally distributed in the summer in England and Ireland. It takes insects at the breeding season, but its chief food is weed seeds, *e.g.*, thistle—its moderately long-pointed bill is well suited for picking the thistle heads,—knapweed, and dock. It is a pity the bird is not in greater numbers.

Bullfinch.—Bullfinch (*Pyrrhula europœa*)—known as "the canon" in Germany from the black patch on the top of the head resembling a priest's skull-cap—takes numbers of weed seeds, but in gardens and fruit plantations can be most destructive by destroying the buds; indeed, fruit-growers rank the bullfinch with the blackbird and the sparrow as their worst enemies.

Protective Measures against Disbudding.

Dusting the buds with quicklime while the plants are still wet after winter washing is a practised method. A suggested spray for protective purposes is described by Mr W. E. Bear,[1]—"60 lb. of quicklime, 30 lb. flowers of sulphur, 12 lb. caustic soda, 10 lb. soft-soap, 100 gallons water. The method of mixing is important. Mix the sulphur into a paste, beating it up well while somewhat stiff, and gradually thinning it, and pour it over the lime. Stir the ingredients thoroughly until the lime is slaked, adding only as much water as is necessary to allow of stirring. Then add the caustic soda, and stir it in until the renewed boiling action which it sets up is finished. Dissolve the soft-soap separately by boiling it in two or three gallons of water, and stir it well in with the other ingredients of the wash, afterwards adding enough water to make up 100 gallons. Pass the mixture through a strainer of fine brass-wire gauze. The lime should be of the best quality and freshly burnt.

"The period for spraying varies with the kind of fruit, the season, and the situation. Gooseberries are generally attacked sooner than plums, and nearer the homestead sooner than farther away. In a mild winter little or no damage is done before the buds begin to swell, but in severe weather birds, from lack of other food, may begin the attack prematurely." January and February may be taken as suitable times for the spraying.

The Sparrow.

The House-Sparrow (*Passer domesticus*).—This bird is a scourge to farmer, gardener, and fruit-grower. The charges against the sparrow may be summarised thus: (*a*) Causes great loss by eating

[1] *Journal of Board of Agriculture*, February 1907, p. 668.

cultivated grain. Especially before harvest time flocks of the birds, young and old, are found in the fields gorging themselves on grain; (*b*) harmful by destruction of the blossom of garden and fruit plants; (*c*) harmful also by its destruction of buds, *e.g.*, gooseberry, cherry, red currant, and later to fruit; (*d*) harmful to such plants as pears, lettuce, cauliflowers, &c.; (*e*) drives away soft-billed birds without in turn doing their useful work; (*f*) chokes up the rhones of houses. Against these charges it is to be admitted that weed-seeds are taken and insects, some of these most injurious ones. As a result of examination[1] of about 1000 house-sparrows taken at different times over a period of 15 years, the following estimate was arrived at the average of the food taken throughout the year:—

Grain . . .	75 per cent.
Seeds of weeds .	10 " "
Green peas . .	4 " "
Insects . . .	6 " "
Other matters . .	5 " "

Abroad, in the United States, in Australia, and in New Zealand, the sparrow has proved a plague. Just as at home here, when it was permissible, poisoned wheat was used against the sparrows, so in Australia wholesale poisoning was resorted to; and in an Adelaide newspaper the sufferers were addressed and exhorted as follows:—

"What means this sadly plaintive wail,
Ye men of spades and ploughs and harrows?
Why are your faces wan and pale?
It is the everlasting sparrows!

No more your wasted fruits bewail,
Your crops destroyed of peas and marrows,
A cure there is that cannot fail
To rid you of the hateful sparrows!

The remedy is at your feet:
Slay them, and wheel them out in barrows,
Poisoned by Faulding's Phœnix wheat,
The one great antidote to sparrows!"

The Board of Agriculture has issued suggestions in connection with sparrow clubs, and evidence generally is overwhelming as to the bird's destructive work and the great necessity for an organised campaign to reduce its numbers.

Tree-Sparrow. — The tree-sparrow (*Passer montanus*) is a rarer and more local species. It is not parasitic on civilisation like the house-sparrow, but building in trees it comes into towns and villages in winter when food fails. It can be distinguished from the house-sparrow thus:—

HOUSE-SPARROW.

Top of head ash-grey; white patch on side of head in the region of the ear; a band of white across the wings.

TREE-SPARROW.

Top of head bright brown-red; the white patch on the side of the head has a black spot on it; two bands of white across the wings.

The Larks (Alaudidæ).

The Skylark or Laverock (*Alauda arvensis*) is a resident species. Being a ground feeder, it is of all our song-birds the best runner, the hind toe or spur being unusually long. Omnivorous in diet, it does good by feeding on insects and weed-seeds; it also takes seed-corn and the young sprouting plants; in severe seasons it can do harm by feeding on the leaves of such plants as swede, and thousand-headed kale.

The Plovers.

The Lapwing, Peewit, or Green Plover (*Vanellus cristatus*) is generally distributed throughout Britain. It is a bird of marsh, moorland, and meadows, and is well known from its cry and flight, and the tuft of feathers at the back of the head. This is one of the most useful birds in the country; it destroys quantities of harmful insects, taking both adults and larvæ; it feeds also on snails and slugs, taking, among the rest, the small snail that is the intermediate host of the liver-fluke.

The Cuckoo (Cuculus canorus).

The Cuckoo, from the cultivator's standpoint, is an entirely useful bird. In addition to other insects, it eats the looper caterpillars of the magpie moth which are not eaten by other birds, and it also takes hairy caterpillars like those

[1] *The House-Sparrow.* By J. H. Gurney and Colonel C. Russell.

of the brown-tail moth and the lackey moth which are destructive to the leafage of a number of trees.

Gulls (Laridæ).

The gulls of the genus *Larus* have three toes webbed, and the fourth high up on the metatarsus. The bill is hooked at the tip of the upper mandible. While normally fish-eaters, gulls are often met with inland, where they are distinctly useful by eating insects. The characters given in the subjoined table will aid identification.

Head.	Back.	Legs and Feet.	Species.
White	black	flesh colour	The Giant Black-backed Gull (*L. marinus*).
		yellow	Lesser Black-backed Gull (*L. fuscus*).
	light-grey	flesh colour	Herring Gull (*L. argentatus*).
		greenish-yellow	Common Gull (*L. canus*).
		crimson	Black-headed Gull (*L. ridibundus*).
Black	light-grey	crimson	Black-headed Gull in summer plumage.

Of these, three may be chosen for reference as found in fields and useful to the farmer.

The Black-headed Gull.—This gull is very common in Britain along the flat shores; it breeds inland in marshes and by rivers. It follows the plough diligently, taking the grubs that are turned up: in addition to its insect diet, the bird, like other gulls, is a scavenger.

The Common Gull (*L. canus*).—This gull is not so common as the last, in spite of its name. In addition to frequenting the sea-coast it breeds also inland by lochs. It is found, like the last, following the plough, and in company with the rook and lapwing. This gull and the black-headed gull resemble one another in plumage in the winter time.

Herring Gull.—The herring gull is widely distributed round the shores of Britain. By the shore it feeds on garbage and carrion; it takes the eggs of cliff birds; out at sea it is said to follow the herring shoals; it is also found inland searching for insects and grubs and worms.

Game Birds.

The Pheasant (*Phasianus colchicus*).—The pheasant is accused of committing havoc amongst corn crops. Its true habits are thus described by Macgillivray: "Its favourite places of resort are thick plantations or tangled woods by streams, where, among the long grasses, brambles, and other shrubs, it passes the night, sleeping on the ground in summer and autumn, but commonly roosting on the trees in winter. Early in the morning it betakes itself to the open fields to search for its food, which consists of the tender shoots of various plants, grasses, bulbous roots of grasses, and *Potentilla anserina*, turnip-tops, as well as acorns and insects. In autumn, and the early part of winter, it obtains a plentiful supply of grain, acorns, beech-mast, and small fruits. In severe weather, however, especially where great numbers are kept, the pheasants require to be fed with grain, when they learn to attend to the call of the keeper.

In the natural state, and in small numbers, pheasants prefer insects and the young shoots of plants to corn, of which they pick at a time only a few grains; but when semi-domesticated, and congregated in large numbers, they assume the habits of the domestic fowl, and will eat and trample down extensive patches of the growing corn in the immediate vicinity of their preserves—and this they do between the ripening and the reaping of the crop. Pheasants devour quantities of wireworm.

Partridge.—The common partridge (*Perdix cinerea*) is troublesome in the corn-fields, but more than compensates by the destruction of insects and their grubs.

INSECTS INJURIOUS TO FARM CROPS.[1]

Insects are Invertebrate animals belonging to the Phylum, Arthropoda or Jointed-footed animals. They have the following characteristics that mark them out from related classes: A body divided into three regions—head, thorax, abdomen; one pair of antennæ; six legs when adult; respiration is by tracheæ; the majority have wings.

The body is covered by a protecting horny material, known as chitin. The head carries the antennæ, the eyes, the mouth parts. The antennæ are sensory and exploring in function; they function very importantly in the sense of smell—a sense by which insects, to a great extent, find their food. The eyes are of two kinds—simple and compound. The simple eyes are borne on the top of the head; "they are confined to the perception of very near objects," and are useful in dark places. The compound eyes, two in number—one at each side of the head—are very complex in structure, having often thousands of facets, each with a lens in association. It is believed, in spite of this, that by these eyes form is perceived very imperfectly, and that the perception of movement and light sensations are their chief uses. Probably no insect can see an object farther away than six feet.

As regards mouth-parts, insects are divided into two sets: the mandibulate insects, which can take solid food by biting jaws, and the haustellate insects, those which take liquid food. The mouth-parts of haustellate insects are modified in various ways, as piercing and sucking, sawing and sucking, and so on.

The thorax of the insect shows three divisions—a front or prothorax, a middle or mesothorax, and a hind or metathorax. Each region of the thorax bears a pair of legs, and the two hind regions of the thorax very commonly carry each a pair of wings. The legs show the following parts: (*a*) the coxa, jointing the leg to the thorax; (*b*) a small trochanter; (*c*) a femur, often stout and strong; (*d*) a tibia, often bristly; (*e*) a tarsus, with a varying number of joints, and ending in claws. The abdomen has in it the bulk of the internal organs, but seldom has external appendages.

Nervous System.—At the head end, on the upper surface, a collection of nerve matter—the supraœsophageal ganglia—form the brain, which supplies nerves to the eyes, antennæ and mouth-parts. From the brain a nerve collar passes round the gullet, on the under side of which is a ganglion, from which a double nerve chord runs backwards along the under surface of the insect; this chord has ganglia along it. These ganglia, present in thorax and in abdomen, control to a great extent the segment in which they are found, and to this extent are independent of the brain. Each ganglion acts as a motor centre for that segment; thus, if an insect lose its head, it can yet fly, walk, breathe. As to sense organs, insects have the sense of sight, smell, taste, touch, hearing; the senses of touch and smell are highly developed.

Respiration.—The air is taken in by means of openings down the sides (as a rule) of the body; the openings are called spiracles, and they lead into tubes known as tracheæ. In many insects the tracheæ are swollen into air-sacs. The air taken in at the spiracles passes through the tracheæ by diffusion, and the free passage of air is aided by the muscular movements of the insect. Advantage is taken of this mode of respiration to kill insects by some contact-insecticide, which chokes up the spiracles, and so suffocates the insect. Birds, while bathing themselves on the highway in sand and fine dried mud and dust, are ridding themselves of insect parasites, whose spiracles get clogged.

Reproduction.—Insects are male and female. Fertilised eggs, typically, are laid to the outside, but in most insects development is not direct; there is a

[1] *The following Figures in this section and other sections dealing with farm pests are, by permission kindly granted, reproduced from Leaflets issued by the Board of Agriculture and Fisheries—viz.*, 633, 637, 638, 643, *and* 655.

metamorphosis. Thus the adult butterfly, known as the imago, lays eggs, from each of which there hatches a larva totally unlike the parent; after a time the full-fed larva passes into a resting condition known as the pupa, which gradually assumes the adult condition. Insects with all these stages in their life-history are known as Holometabolic. With some insects the metamorphosis is incomplete; the imago lays eggs from which come tiny young forms resembling the parent externally; this young form feeds and grows and moults until after the last moult maturity is reached without any resting pupal stage. Such insects are known as Hemimetabolic.

In the larval condition feeding is voracious, many larvæ eating more than their own weight in a day. To different kinds of larvæ different names are applied: thus a larva with numerous legs is known as a caterpillar, one with six legs and biting jaws as a grub, and one without legs a maggot. Once the adult mature state has been attained, there is no further growth, although the adult insect may live for a long time.

CLASSIFICATION OF INSECTS.

Insects may be divided into Orders, the wing characters being made the basis of classification. The Orders are—

Order.	Metamorphosis.	Mouth-Parts.	Examples.
Thysanura and Collembola.	No metamorphosis.	Fitted for biting, but withdrawn into the head.	Springtails.
Coleoptera.	Complete.	Mandibulate.	Beetles.
Hymenoptera.	"	Bite, and may also suck.	Bees, wasps, ants.
Orthoptera.	Incomplete.	Biting.	Cockroaches and earwigs.
Neuroptera.	Complete or incomplete.	Biting and sucking.	Dragon-flies, May flies, caddis flies.
Lepidoptera.	Complete.	Haustellate.	Butterflies and moths.
Diptera.	Complete.	"	Flies.
Thysanoptera.	A slight metamorphosis or none.	"	Thrips.
Hemiptera.	Incomplete.	"	Aphides and scale insects.

Orders containing Insects of importance in Agriculture.

Collembola.—These are wingless insects with no metamorphosis; the jaws are pushed back into the head. Carried below the body, with its tip pointing forwards, is a process known as the spring; as this spring is straightened out the insect is sent with a leaping movement into the air.

Coleoptera or Sheath-winged Insects.—Wings 4, the front pair horny and serving as wing covers or elytra; hind pair used in flight. The larva is a grub with 6 legs and biting jaws, or, as in the weevils, legless, and with a curled, wrinkled body.

Hymenoptera or Membrane-winged Insects.—Wings 4, the front pair larger; all 4 wings used in flight. The larva may be a legless grub—*e.g.*, bee, wasp, ant, ichneumon flies; or a caterpillar with more legs than 16—*e.g.*, sawflies; or a grub with 6 very short legs, and living in the wood of trees—*e.g.*, wood-wasp. The females have an egg-laying tube at the end of the body, which is sometimes modified as a sting.

Lepidoptera or Scale-winged Insects.—Wings 4, all used in flight, and covered with scales. The larva is a 16-legged caterpillar (only the front 6 are true legs, the others are skin projections), or some of the abdominal legs may be absent, in which case the larva is known as a looper or geometer.

Diptera or Two-winged Insects.—Wings 2; the hind pair of wings replaced by two balancers. The larva is a legless maggot with pointed head end and blunt hind end.

Thysanoptera or Fringe-winged Insects.—Wings 4 and alike; they are

narrow and have fringes; mouth-parts pierce and suck.

Hemiptera.—Wings 4. The four wings may be alike and membranous, and are held over the back when the insects are at rest — *e.g.*, aphides; or the wings may be dissimilar, the front pair stiff and horny, except at the tip, and the hind pair membranous, and when the insect is at rest the wings are folded flat on the back—*e.g.*, the bugs.

CROP PESTS.

Bean Aphis or *Collier* (Aphis rumicis, Linn.)

The attack by this aphis (fig. 632) is begun by wingless females, which

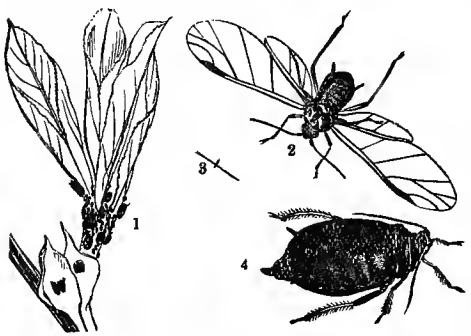


Fig. 632.—Bean Aphis (*Aphis rumicis*, Linn.)
1, Bean-shoot, with aphides; 2, Male, magnified; 3, Natural size; 4, Wingless female, magnified.

establish themselves near the top of the bean stalks at flowering time. These produce living young, and as one generation succeeds another the upper part of the plant soon becomes coated with the colliers. When this overcrowding takes place winged viviparous females appear, which spread the infection to other bean plants and to such wild plants as dock. A sexual generation is produced towards the end of the year, the eggs being laid on wild plants, and from these in the next year infection comes to the beans. In addition to the loss of sap from the feeding of the aphides, the plants are spoiled by the sticky honey dew.

Treatment.—The infested tops of the beans should be cut off as soon as "the colliers" appear. This treatment is very successful, if care is taken to carry off the infested tops and to destroy them. Spray with soft-soap, quassia, and water.

General Treatment for Aphides or Plant Lice.—In dealing with the attack of aphides, treatment should be immediate, because in favourable weather-conditions multiplication is exceedingly rapid, and as attacked leaves curl over, the aphides receive protection and the spray does not reach them. A soft-soap wash is an excellent means of getting rid of aphides, 6 to 10 lb. of soft-soap in 100 gallons of water. Against such as give off quantities of honey dew quassia should be added. Boil 6 to 8 lb. of quassia chips to extract the bitter principle, and then pour into the 100 gallons of soft-soap wash. One of the very best sprays against aphides is paraffin emulsion.

How to make Paraffin Emulsion.—Dissolve ½ lb. of soft-soap in 1 gallon of boiling water, and whilst still hot add 2 gallons of paraffin; churn violently till a creamy liquid is formed. This is the stock, which for use should be diluted with 5 to 50 times its bulk of water, according to the time of the year and the nature of the plant —tender or hardy.

Mr Pickering, in the *Eighth Woburn Report*,[1] recommends as a formula for paraffin emulsion: iron sulphate, 10 ounces; lime, 5 ounces; paraffin (solar distillate), 16 to 24 ounces; water to make up to 10 gallons. Dissolve the iron sulphate in about 9 gallons of water; slake the caustic lime with a little water, making it into a milk, and run it into the iron sulphate solution through a piece of sacking; then churn the paraffin into the mixture. This should be tested, before use, for any unprecipitated iron, by adding to some of the material a few drops of potassium ferricyanide; if there be iron in solution a blue coloration results (Prussian blue), and a little more lime-water should be added and the test repeated.

[1] *Eighth Report, Woburn Experimental Fruit Farm*, 1908, pp. 29, 93, 127.

BEAN AND PEA BEETLES.

Bean Beetle (Bruchus rufimanus).

This beetle (fig. 633) measures about 1/6 inch. The ground colour is black, with a pubescence of brown hairs. The pea beetle (*Bruchus pisi*) resembles it, but the bean beetle has the thighs of the front legs red and the exposed tip of the abdomen nearly covered with white grey pubescence, while the tip of the abdomen of pisi has marked dark spots, and its thighs are black. The larva in

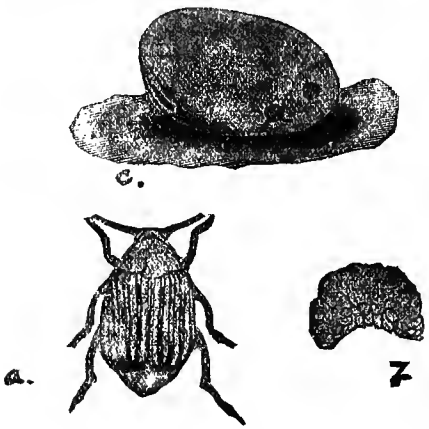


Fig. 633.—The Bean Beetle.
a Beetle, and *b* Grub, magnified.
c Exit holes of beetle.

both species is a fleshy wrinkled whitish-yellow grub; it has a horny head and biting jaws.

The eggs are laid in each case on the pods when these are very young; the grub, on hatching, passes into the seed and completes its growth there; pupation also takes place in the seed, the position being marked by a little round depression in the skin. A round hole marks the place of the exit of the adult.

Treatment.—(1) Do not sow peas or beans containing the beetles. (2) The pests can be killed in the peas or beans by fumigating these with bisulphide of carbon. The seed to be treated should be placed in an air-tight receptacle and some bisulphide of carbon placed in a saucer, the saucer being then laid *on the top* of the peas or beans, and the receptacle closed and kept closed for twenty-four to forty-eight hours. The heavy poisonous fumes pass down through the material and kill the pests.

One lb. of bisulphide of carbon will do for 100 bushels, or in smaller quantities 1 oz. for 100 lb.

Bisulphide of carbon fumes are poisonous to human beings, and explosive if a naked light be brought near.

Bean Weevils (Sitones)—see p. 459.

Beet Carrion Beetle (Silpha opaca).

Beet and mangold crops are sometimes attacked by the beet carrion beetle, which begins to prey upon the leaves as soon as they appear above ground, giving great trouble to the sugar-beet growers in France. The beetle measures about 2/5 in.; it is black, with yellow hairs; the wing-covers have three raised lines on each.

The grubs are much like wood-lice in shape, black, and about 3/4 of an inch long when full grown.

Prevention.—As the eggs are laid in putrid matter, it is advisable (to avoid repeated attacks) to put the manure on in autumn, and only use artificial at the time of sowing. Stronger manures, such as offal and sea-weed, or shore refuse, may bring it; and as it winters in decayed leaves, they should be removed. Spray with paraffin emulsion (see p. 444).

When the mangolds are swept off in the seed-leaf stage, it is advisable to put in immediately another kind of crop. Turnips, carrots, parsnips, potatoes, peas, beans, and cabbage have been recorded as succeeding perfectly on land where the mangolds had been destroyed.

The Carrot Fly (Psila rosæ).

This fly measures 1/5 inch in length; the wings are iridescent and have yellowish-brown veins; the colour of the body is black or dark green; the head and legs are yellow. The larva is legless and smooth; at the pointed head end are two curved hooks used in feeding; the hind end is blunt, and has two small spiracular plates. The puparium is light-brown and wrinkled, and has two small black spiracular plates.

The first brood of flies issues in spring from puparia that have lain over winter in the soil. The eggs are laid on the carrots a little below the surface of the

ground. The maggots bore into the root, making, especially in the under parts, winding tunnels which get filled with excrement, and soon the rotting which follows is accompanied by a nasty smell, and, if the carrot be eaten, it has a disagreeable taste. The tunnels show a rusty colour. The larva on being full fed leaves the carrot and pupates in the soil. There is more than one generation in the year.

Treatment.—An excellent preventive measure is to spray with paraffin emulsion (see p. 444). The carrot-bed should be sprayed after sowing, again after germination, and a third time after thinning. Or sand and paraffin can be sprinkled over the plants (see "Onion Fly," p. 459).

Carrots seen to be attacked — the withering and yellow colour of the leaves will be a guide—should be removed from the ground; the removal, however, should be done in good time and carefully. The careless wounding of the roots may be a means of promoting attack, as the odour from the wounded carrots gets into the air and acts as a guide and an attraction to the carrot flies. This is partly why the pest is worst at thinning-time, as thinning means a good deal of bruising of the plants. One should thin early or thin late, and after thinning leave the soil well compacted, so as to make it difficult for the fly to reach the roots for egg-laying. In connection with the last suggestion, we received some time ago a communication which read: "For the past two years I have left a portion of the carrots in my garden unthinned, only pulling them from time to time for use. I found that portion of the crop untouched by maggots, while the portion thinned was. Of course the unthinned carrots were not so big as they might have been." A turning up of the soil, after infestation, in the winter time would expose any over-wintering pupæ; while the burying of the surface soil would leave any puparia that might be present at such a depth that even if the pupa-cases gave out their flies these would not be able to make their way above ground.

For Wireworm in carrot, see p. 453.

Beet and Mangold.

The Pigmy Mangold Beetle (*Atomaria linearis*).—This beetle now and again does immense damage to the mangold crop, sweeping off the whole crop when it is in the seedling and young stage. The beetle is so small that it is very often never seen, and the damage ascribed to something else. The young plants are gnawed in the parts below the soil, and the leaves are also eaten. The life-history is uncertain, but the grubs probably live in the soil, while the beetles live in the soil round about the plants, but also come above ground.

Treatment.—If the crop be hopelessly infested, plough it in deeply. On the Continent thick seeding is practised where this insect is a pest. The young plants should be dressed with soot, and then the soil round the plants hoed in. As an experiment, we should suggest steeping the seeds for a short time, before sowing them, in paraffin.

Mangold-leaf Maggot. — Another well-known beet and mangold pest is the maggot of the *Pegomyia betæ*, Curtis (fig. 634). This damages the crops by

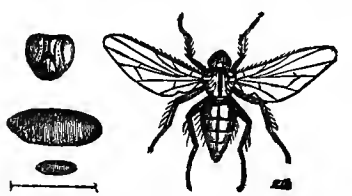


Fig. 634.—Beet-fly (*Pegomyia betæ*, Curtis).

Female, magnified; Line showing spread of wings, natural size; Head, magnified; Pupa, natural size and magnified.

feeding, between the upper and lower epidermis, on the tissue of the leaf. The white legless maggots are about ⅓ of an inch long, and of a yellowish-white colour, and as soon as they are hatched bore through the skin of the leaf by the aid of two mouth hooks. There are two broods in the year.

Treatment. — Pull and burn badly attacked plants. Spray with paraffin emulsion (see page 444) as a preventive. Keep down Composite and Chenopodiaceous weeds, as these may harbour the enemy.

Cabbage Butterflies.

Cabbage very often suffer from cabbage-butterfly attack. We give illustrations of

the two principal offenders, — the large white cabbage butterfly (*Pieris brassicæ*, Latreille) (fig. 635) and the small white

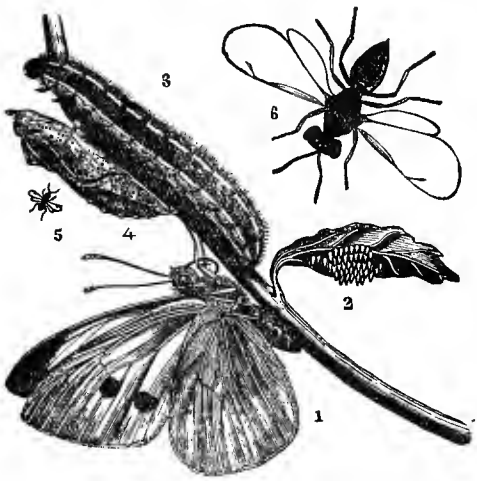


Fig. 635.—Large White Cabbage Butterfly (*Pieris brassicæ*, Latreille).

1, Female butterfly; 2, Eggs; 3, Caterpillar; 4, Chrysalis; 5 and 6, Parasite Chalcid-fly (*Pteromalus brassicæ*), natural size and magnified.

cabbage butterfly (*Pieris rapæ*, Latreille), (fig. 636). Leaves on which the eggs are laid should be picked off, and the caterpillars searched for and destroyed. The caterpillars are more common in gardens, where they find congenial shelters, than in large open fields. Measures to promote a healthy growth should be adopted.

1. The Ichneumon fly (*Microgaster glomeratus*) comes to our aid as a natural enemy to these caterpillars, in which it lays its eggs. The maggots from these eggs feed inside the caterpillar, and as a result the metamorphosis is not completed. The small yellowish cases, collected in bunches, often seen on cabbages, are those of the ichneumon pupæ. They should not be destroyed.

2. The great *measure of prevention* is searching for the chrysalids, which may be sometimes collected in handfuls from shelter-places under eaves, boards, &c., in the neighbourhood of gardens.

3. Sending boys to hand-pick the caterpillars has been found useful as a remedy.

4. Destroy the egg clusters.

5. A good drenching with ordinary water is often useful, as it causes the caterpillars to suffer in health. Some drench with soap-suds.

The Cabbage Moth (Mamestra brassicæ).

The destructive caterpillars of this moth are general feeders, found not only on cabbage, which is the commonest host plant, but on other cruciferous plants and on fruit plants and garden flowers. The caterpillars have 16 legs; they measure 1¼ inch when full grown, and have a habit of rolling themselves into a ring when they are touched: the colour varies, green or grey-green above and yellowish below, with a dark line down the back. The pupa, shining chestnut brown, is in the soil. The caterpillars eat into the heart of the cabbages, and the plants are made disgusting by the excrement.

Treatment.—1. Hand-pick the caterpillars before they get into the heart. 2. Dust the plants with lime. 3. Destroy the pupæ when the ground is dug in winter. Poultry turned on to the land at this time would be helpful.

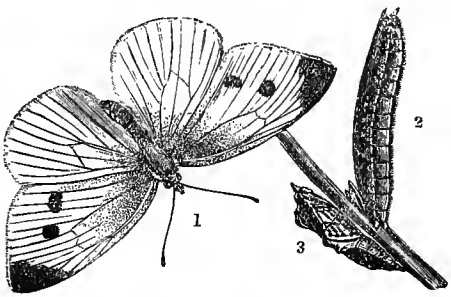


Fig. 636.—Small White Cabbage Butterfly (*Pieris rapæ*, Latreille).

1, Female butterfly; 2, Caterpillar; 3, Chrysalis.

Cabbage Root Fly (Phorbia brassicæ).

This (fig. 637) is one of the most troublesome enemies of the cabbage: not only are the maggots found infesting cabbages, but turnip, swede, cauliflower, brussels-sprouts, radish, are all attacked.

The plants are checked in their growth, the leaves discolour, wither, wilt, and the infected parts rot and the plant falls away.

The maggot, which does the harm, is whitish-yellow and legless; the head end is pointed, and has two dark curved mouth hooks; the hind end is truncate, the last segment having two dark spiracles; all round the edge of this last segment are 12 little projections (seen with a lens),—the two lowest are the largest and are forked. The full-grown maggot measures ¼ inch. The puparium is brown in colour and oval.

The females lay their eggs close to the plant; the maggots bore into the plants, making galleries in the roots; they may be found, too, tunnelling in swede leaf-stalks. Pupation takes place in the soil or in the infested plant. There is more than one brood in the year, the first flies showing about the end of April.

Treatment.—Successful treatment is extremely difficult. In America the cabbages and cauliflowers are protected by having tarred paper or cards placed round them; the flies are not able to get near enough to lay their eggs. This treatment has proved too expensive in Britain.

In garden cultivation a cupful of paraffin should be added to a pailful of sand, and the sand sprinkled once a-week round the stems of the cabbages, as a deterrent from egg-laying. Remove and burn badly infested plants. After bad attack do not follow with a crucifer crop. Very early sown plants are noticed largely to escape.

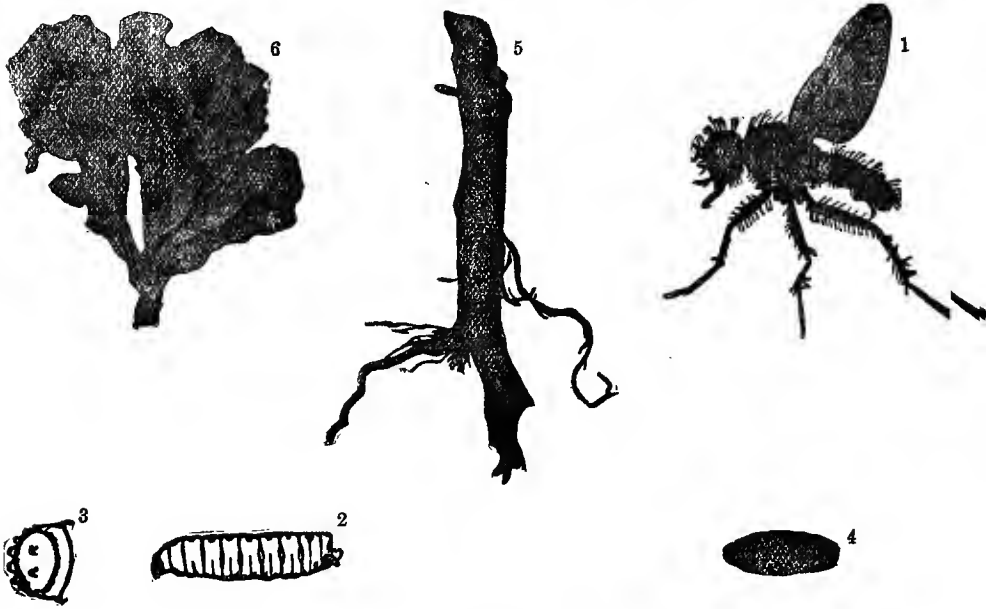


Fig. 637.—The Cabbage Root Fly.

1. Male fly, greatly magnified.
2. Maggot, magnified.
3. Last segment of maggot, enlarged, showing tubercles.
4. Puparium, magnified.
5. Attacked cabbage with larva *in situ*.
6. Withered leaf of attacked cabbage.

(Figs. 1 and 3 after Slingerland.)

Cabbage Root Gall Weevil (*see* Turnip Gall Weevil).

The Cabbage Flea Beetle (*Haltica oleracea*) is glossy bright blue-green in colour; it measures from 1/7 to 1/6 in. in length. The adult beetles feed on the leaves not only of seedling but of older plants. The grubs feed externally on the leaves. Turnip is attacked as well as cabbage. There are a number of broods in the year.

Cabbage Aphis (Aphis brassicæ).

This aphis, which has a white mealy coat, is a pest on cabbages. The infested leaves pucker and blister, and the plants are spoiled by their being covered with the honey dew excreted by the aphides.

Treatment (*see* Treatment for Aphides, page 444).—There are natural enemies (*see* Useful Insects, page 469) of the aphis—viz., hover-fly larvæ, which eat the aphides, and Ichneumonidæ, whose larvæ are parasitic inside them.

The Celery Fly (Acidia heraclei).

The maggots of this fly (fig. 638) mine the leaves of celery and parsnips, causing blister-like patches, pale at first but brown later. The eggs are laid by the female fly on the upper surface of the leaves; the pale-green larvæ hatch in a week, and are full grown in another fortnight, the puparium being found in the leaf, or in the soil if the full-fed maggot has fallen away. There are several broods in the year.

Fig. 638.—The Celery Fly.

1. Fly, magnified.
2. Larva, magnified.
3. Pupa, natural size.
Lines showing natural size of fly and larva.

Treatment. — (1) As a preventive measure the plants should be sprayed with paraffin emulsion, to deter the fly from egg-laying. (2) Spoiled plants should be burned with the enclosed larvæ or pupæ. (3) When the crop is removed, the surface-soil should be buried deeply, so that the flies from buried puparia will be unable to reach the surface.

The Cereals.

Daddy-long-legs or Crane-flies (*Tipula*).—The larvæ of the crane-fly, known as leather-jackets, are often the cause of great destruction to cereal and grass crops, and to plants of other Natural Orders as well. The Tipulidæ or Crane-flies are the large, sprawling, awkward flies seen in greatest numbers from August; the name Crane-fly is given to them from the snout that projects somewhat from their head, and from the long legs.

There are several species of Tipula, the best-known three being *T. oleracea* (fig. 639), *T. paludosa*, and *T. maculosa*. All three may be present, or two of them, at the same time, or infestation in a district may be due to only one of them.

The general life-history is that the females lay numerous eggs on the ground, pasture and coarse rank herbage being favourite places. From the eggs hatch larvæ which live in the soil, gnawing the roots of plants; they may come to the surface at night and destroy leaves, *e.g.*, the young leaves of corn. Among the many different plants attacked are corn, grass, turnip, pea, bean, clover, mangold. The larvæ are earth-coloured or rust-coloured, and have small hard heads, with short antennæ; the head carries a strong pair of mandibles, which bite against the teeth of another pair of jaws; this head can be retracted within the segments that follow it. Round the margin of the hind end of the leather-jacket are little projections, and on the hind surface of the last segment are the two spiracles;

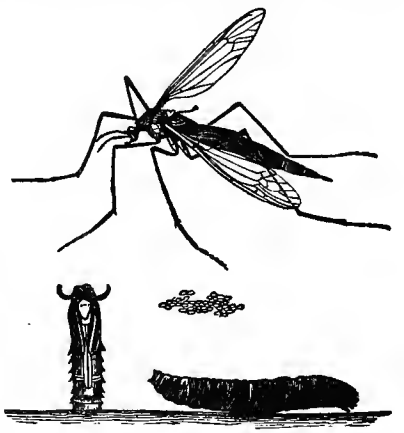


Fig. 639.—Daddy-long-legs (*Tipula oleracea*, Linn.)
Fly (after Taschenberg); Pupa and larva (after Curtis).

the tough, strong skin is very resistant to external influences.

When this larva is full fed it moults its last skin and becomes a pupa. After a short resting-stage—it may in the summer be only a fortnight—the pupa, by the aid of a series of little hooks on the abdominal segments, wriggles to the surface, where it may be seen standing erect with quite half of the body projecting above the surface. The head end carries two little tracheal horns by which respiration is accomplished. At length the skin cracks on the upper surface at the front end, and the mature crane-fly issues.

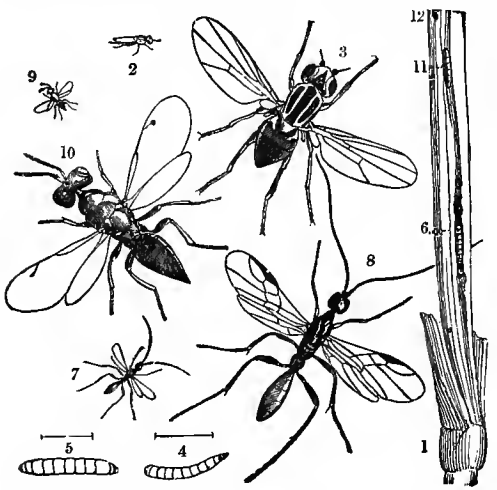


Fig. 640.—Ribbon-footed Corn-fly; Gout (*Chlorops tæniopus*, Curtis).

2–6, Larva, pupa, and fly of *Chlorops tæniopus*, natural size and magnified parasite flies; 7 and 8, *Cœlinius niger*; 9 and 10, *Pteromalus micans*, natural size and magnified; 1, 11, and 12, Infested corn-stem.

Treatment. — Close grazing in the autumn in order to discourage egg-laying. The absence of a rank growth will tend to reduce egg-laying. "Grub-on-corn," as the pest is often called, is worst on corn after grass, and the females should be deprived of their chance of laying on pasture by having the land ploughed, if possible, before the flies in large numbers have proceeded to their egg-laying in August and September. Failing the possibility of a ploughing early in the autumn, it is recommended to dress grass and clover leys with gas-lime, three to four tons to the acre; this is fatal to eggs and larvæ. In the north there is in some years great loss of crop from the leather-jackets, and some practise late sowing to give the leather-jackets a chance to have done a great part of their feeding on the roots and leaves of the ploughed-up pasture before the young oats are ready for them. As a remedial measure, when the pest has got to work in the young oats the crop should receive a dressing of nitrate of soda, 1 to 2 cwt. to the acre. When the crop is evidently beyond saving, it should be ploughed up and some other crop taken. The crop planted will differ according to the locality and the conditions, but white turnip, rape, and mustard have been recommended. Harrowing and rolling kill some of the grubs, and turn others up for the birds; where rolling is practised (with a heavy roller) it should be done at night, or very early, as the larvæ will be found at or near the surface. Professor Carpenter,[1] in a laboratory experiment, found that if powdered naphthalene were mixed with the soil the leather-jackets succumbed. Fumigants, containing naphthalene as an ingredient, may prove helpful as a mode of treatment against soil insects.

Gout-fly or The Ribbon-footed Corn-fly (*Chlorops tæniopus*).—This fly (fig. 640), ⅛ inch long and ¼ inch in spread of wings, is, in general colour, yellow, with the antennæ black; there are three black longitudinal stripes on the thorax. The flies lay their eggs in May and June on young barley plants —other cereals and grasses may be used, —and the maggot, on hatching, tunnels its way down the stem, from the base of the ear to the first knot in the stem. The maggot is legless, whitish-yellow in colour, and with two tubercles at the hind end. The full-grown maggot pupates at the bottom of the burrow, the flies appearing in autumn. This brood of flies lays on wild grasses, and it is from these that the first brood of flies of the year comes in the next season. As a result of attack on barley, the ears

[1] *Economic Proceedings of the Royal Dublin Society*, August 1905.

may be unable to break through the enveloping sheaths, this giving a characteristic swollen appearance.

Treatment.—Sow early, in order that the plants may be well on before the appearance of the flies; plants whose ears have broken through before the flies appear are safe. The refuse from a threshed infested crop should be burned.

Frit-fly (*Oscinis frit*).—This fly (fig. 641) measures less than ⅛ inch in length. The body is shining black; the legs also are black, except the feet, which are yellow-brown. The maggots of the fly are injurious to cereals and pasture grasses. In Britain the chief damage is to oats, although barley may also suffer. Symptoms of attack are pale spots on upper surface of leaves that are still green, a reddening or browning of the leaves, stunted growth, and at last failure: tillering may take place, but the shoots are twisted and swollen.

The first flies of the year appear in April and May to lay their eggs on the young leaves of the oat. The maggot is round, fleshy, and legless; it has two mouth-hooks at the head end, and at the blunt hind end two projecting spiracles. The maggots eat to the heart of the plant by means of their mouth hooks. The full-fed maggots, ⅛ inch in length, pupate in the infested plant, and the flies of the new brood appear in July. These new flies lay on pasture and wild grasses, or in the ears of oats and barley, if these be in a suitable stage with young grains. The result of attack on the ears is a light sample, with shrunken, shrivelled grains. By August and September a third brood of flies may appear, and these lay on grasses from which infestation of the oat will follow in the next April and May.

Treatment.—Sow early, so that the plants may get a start before the fly. The late Miss Ormerod quotes cases thus: "All early spring fields seem to have escaped, in some others sown late 90 per cent of the crop is gone"; and again, "One field of oats sown on 29th March enjoyed almost complete immunity; and in another field, sown on 29th April, over 70 per cent of the first stems were destroyed." A stimulating dressing may save the plant if the attack is noticed early, but badly infested plants are doomed, and should be ploughed in deeply. Frit-flies found swarming in granaries, stores, &c., that have issued from puparia in harvested corn should be destroyed. Destroy such wild grasses, in the winter, as are known to be infested.

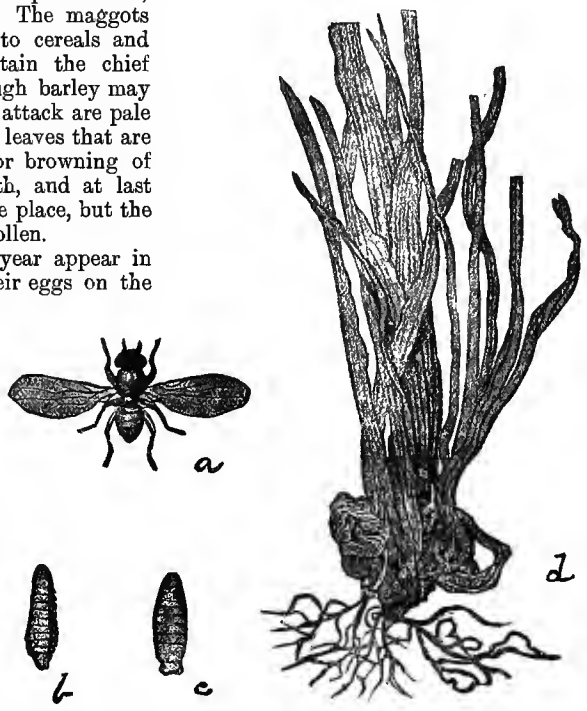


Fig. 641.—The Frit Fly.
a The Frit Fly (*Oscinis frit*). *b* Larva. *c* Puparium. *d* Young infested plant. *a b c* Much enlarged.

Wheat Bulb-fly (*Hylemyia coarctata*).—This fly, which measures ¼ inch in length, lays eggs on young wheat plants, and the maggots feed inside the stems. The puparia are found both in the soil and in the spoiled plants. At present we have no known remedial measure against this insect. The other cereals, oat and barley, are not attacked.

Hessian Fly.

In 1886 a new pest was discovered in England. The Hessian fly (*Cecidomyia destructor*, Say) (fig. 642) was found to be present in some barley-fields near Hertford.

The following abstract, from a German source, gives its life-history: "The larvæ live in the haulm of wheat, rye, and barley. The female flies usually lay their eggs on the young leaves twice in the year—in May and September,—out of which eggs the maggots hatch in fourteen days. These work themselves in between the leaf-sheath and the stem, and fix themselves near the three lowest joints, often near the root, and suck the juices of the stem, so that later on, the ear, which only produces small or few grains, falls down at a sharp angle. Six or eight maggots

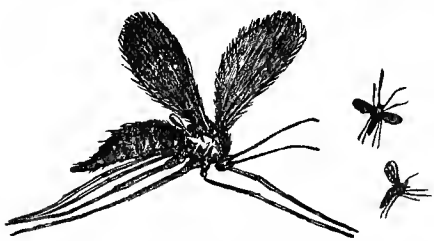


Fig. 642.—Hessian Fly (*Cecidomyia destructor*, Say). Natural size and magnified.

may be found together, which turn to pupæ in spring or about the end of July, from which the flies develop in ten days." —(*Stett. Ent. Zeit.*, xxi. p. 320.)

Miss Ormerod (from whose pamphlet on the subject this information is taken) found, on visiting the infested fields, the stems doubled sharply down a little above the joint; and between this double and the joint there lay, closely pressed to the stem and covered by the sheathing-leaf, the flax-seed-like puparia. The injury is caused by the fly-maggots, lying at the same spot, sucking the juices from the stem, which is thus weakened, and falls.

The Hessian fly has commonly two broods in the course of the year—the winter attack to the young plants, and the summer attack to the growing straw. The flies which come out in August or September from the "flax-seed" chrysalis-cases (sheltered above the second joint of the straw from the ground) lay their eggs, we are informed by various observers—the late Professor Riley amongst the number,—in the grooves on the surface of the leaves, or between the stalk and sheath where loose, and as soon as the footless larva or maggot hatches, it makes its way down the leaf to the base of the sheath, which in the young winter wheat is at the crown of the root.

This form of attack has not yet been reported in England. The summer attack with us is started chiefly from "flax-seeds" or chrysalids which have survived the winter. The flies from these "flax-seeds" come out in spring, or about the beginning of May, and as, where the corn is running up to stem the tender ground leaves are no longer to be found, which are used for autumn egg-laying, the flies have no choice, but they lay them instead, as we know, so that the maggot, when hatched, shelters itself between the stem and sheath, just above the first or second joint from the ground, and there it turns to the flax-seed chrysalis, from which the autumn brood presently comes out.

Prevention.—A chief method of prevention is in *late sowing, so that the young wheat will not be up until the autumn brood is over:* this is a most important precaution. All measures to secure hearty good growth are very desirable; so is rotation of crop, and it should be borne in mind that strong-stemmed corn is less liable to attack than the kinds of which the outside is more readily injured by the maggot.

One most important measure to prevent recurrence of attack from infestation present in any locality is *destruction of siftings*, in which the flax-seeds, as they are called, are thrown by the threshing-machines. These chrysalids are often present in great numbers, and would, if left, be the origin of next year's attack; and if burnt together with the rubbish in which they lie, great danger will be spared. Where there has been infestation the stubble should be ploughed in deeply.

The Wheat Midge (*Diplosis tritici*). —The adults measure $^1/_{25}$ to $^1/_{16}$ of an inch; they are yellow in colour, with antennæ black; the two wings are hairy. The female midge (fig. 643), recognised by her hair-like projecting egg-laying

tube, lays the eggs in summer time in the flowers of grasses, wheat, and rye, rarely

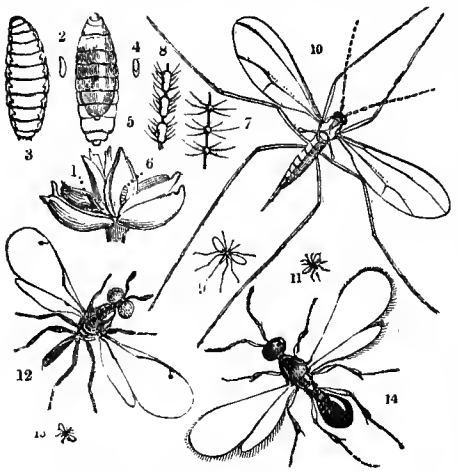


Fig. 643.—Wheat Midge (*Cecidomyia* (*Diplosis*) *tritici*, Kirby).

1, Infested floret; 2–6, Larva and cased-larva (? pupa), natural size and magnified; 7 and 8, Joints of antennæ, magnified; 9 and 10, *C. tritici*, natural size and magnified. Parasite flies: 11 and 14, *Platygaster tipulæ*; 12 and 13, *Macroglenes penetrans*,—natural size and magnified.

oats and barley. Several eggs are laid in each flower, and the maggots live, inside the flowers, on the grain; they are legless, and in colour orange; on the under surface at the front end there will be seen under the microscope a process bifid at the apex, and known as the breast-bone or anchor process. The full-fed maggots pass into the soil for pupation, or they may be harvested with the grain. Ears which have been infested are light.

Treatment.—Deep ploughing of the stubble of an infested crop to bury the puparia. The refuse and chaff after threshing should be burned, as where there has been an attack maggots and puparia may have been carried in in the crop. From any collection of screenings and refuse containing puparia the flies will issue in the next season, and may pass to the crop for their egg-laying.

The Corn Sawfly (*Cephus pygmæus*). —The sawflies are Hymenopterous, not Dipterous, insects. The corn sawfly (fig. 644) is a four-winged insect, black in colour, spotted with yellow; it measures ⅓ of an inch in length. The female makes a hole in the stem—wheat especially is attacked—whilst the stem is young and soft. The larva which hatches is legless, and yellowish-white in colour, with the head yellow-brown; it tapers to the hind end. The larva tunnels the stem, piercing the knots in its passage; when full fed it passes to the base of the stem, to the part which will be left as stubble, and passes the winter in a cocoon of silk. Before spinning this cocoon the larva gnaws the stem through in a circle, above the place where it will lie—about the ground-level. As a result of this, the stem falls over. In the next spring the larva which has hibernated as such pupates, and the adult issues about May. Loss in grain from the twisted state of the straw follows attack.

Treatment.—Burn the stubble, or bury it deeply, so as to destroy the hibernating larvæ and prevent a new infestation.

Wireworms.—These are among the very worst pests of the farm. Some insects can be fought by altering the rotation, but the wireworms destroy all kinds of crop irrespective of plant relationship—cereals and grass, potatoes, turnips, hop, mangold, carrot

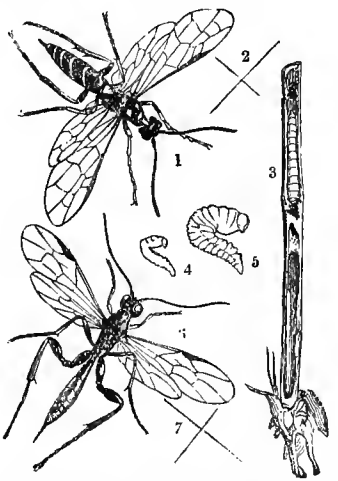


Fig. 644.—Corn Sawfly (*Cephus pygmæus*, Curtis).

1 and 2, Sawfly, magnified and natural size; 3, Stem containing larva; 4 and 5, Larva, natural size and magnified; 6 and 7, Parasite fly (*Pachymerus calcitrator*), magnified and natural size.

(fig. 645). These wireworms are the larvæ of the beetles known as Click

beetles; they are elongated worm-like forms, with biting jaws, three pairs of thoracic legs, and a fleshy sucker at the

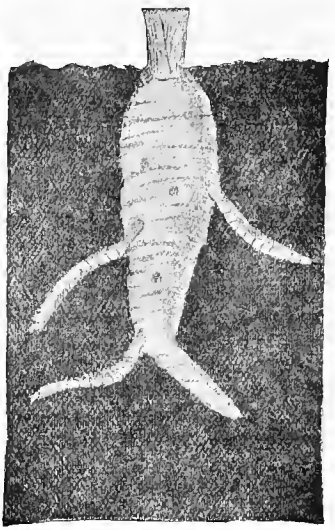


Fig. 645.—Wireworm on carrot.

downwardly bent tail end, which aids in progression; the joints have horny shields on upper and lower surface for protection. In colour these larvæ are yellow-brown.

Click Beetles.—There are several species of click beetle—*e.g.*, *Agriotes* (*Elater*) *lineatus* (fig. 646), which is ⅜ inch long and ½ inch in spread of wings; the wing-cases are brown and have yellow-brown stripes; the legs are rusty red.

A. obscurus, black, but covered with brown hairs; the upper parts of the legs are black, the rest rusty red.

A. sputator is rather smaller; it is black, with red legs.

Athöus (*Elater*) *hæmorrhoidalis* is larger than the other species; it is pitchy-black or brown and hairy, the wing-cases are lighter; characteristic are the red-brown tip of the abdomen and edges of the wing-cases.

The dingy colours of the beetles and sluggish habits prevent them from being noticed on plants. If touched they drop to the ground. If the beetle fall on its back, and there is nothing within reach that it can catch on to by means of its short legs, a spring apparatus on the under side of the body, consisting of a curved spine which fits into a groove on the mesothorax, is brought into play, and the beetle rights itself. It raises the middle region of the body so that the spine comes out of the groove, then the body is suddenly straightened, the spine being forced back into the groove with a click—hence the name click beetles,—and the cases of the wing-covers striking the ground smartly, the beetle is sent into the air, and when it falls it lands on its feet.

The beetles lay their eggs close to the roots of plants, and the grubs on hatching feed by tearing away the soft parts and tunnelling into the tissue. Several years are spent in the larval condition, the wireworms moving from plant to plant. In the winter they go deeper, but on the return of mild weather come nearer the surface again to renew their feeding. When full fed the wireworm goes deeper into the soil and becomes a pupa under cover of a cocoon of soil particles: in due course the mature beetle makes its way to the surface.

Treatment.—Attack is worst in clover-leys or broken-up pasture. Wireworms should be anticipated under these circumstances, and preparation made by feeding the pasture as bare as possible before ploughing and spreading gas-lime on the

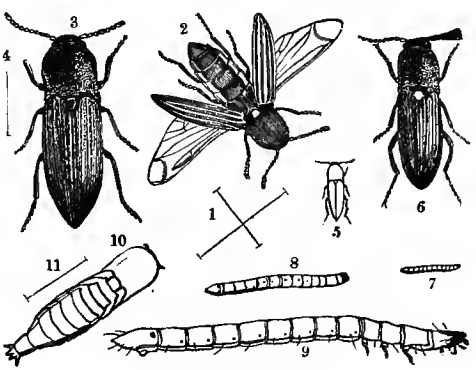


Fig. 646.—Click Beetles.

1 and 2, *Agriotes* (*Elater*) *lineatus*; 3 and 4, *A.* (*E.*) *obscurus*; 5 and 6, *A.* (*E.*) *sputator*, natural size and magnified; 7, Larva of *A.* (*E.*) *sputator*(?); 8 and 9, Larva of *A.* (*E.*) *lineatus*, natural size and magnified; 10 and 11, Pupa of wireworm magnified—the straight lines show natural length.

surface—the gas-lime must be allowed to lie some weeks before it is ploughed in. Some attempts have been made to combat the pest by a fumigant named vaporite (Strawson). For arable land the vaporite is sown broadcast before the plough, and some time in advance of seed-sowing: the vaporite is mixed with the soil to the depth of 4 to 6 inches at the rate of 2 to 3 cwt. per acre. In gardens the vaporite is dug in. The action of vaporite is said to be slow, and therefore the material should be applied early.

The beetles may be trapped in gardens by being lured to little bundles of the crop plant that have been steeped in Paris-green, or little heaps of clover are laid here and there to be used for shelter and egg-laying: the trap material in each is covered with a board.

Many birds do good by devouring wireworms—*e.g.*, peewit, gulls, starling, rook (see Birds and their Food Habits).

The Cockchafer (*Melolontha vulgaris*).—The large white grubs of this beetle feed at the roots of cereals and grasses as well as on nursery forest-trees; the grubs have six legs, a horny head, and strong biting jaws; they lie in a curved position, and their bodies are swollen and dark in colour from food contents at the hind end.

The Garden Chafer or Bracken Clock (*Phyllopertha horticola*). — The chafer or beetle is about ⅓ inch in length; it is shining greenish-black in colour, with blackish or grey hairs; the head and thorax are glossy blue-green; the wing-covers yellow-brown. The grub is whitish, fleshy, wrinkled, with a brown head and gnawing jaws; it has three pairs of short legs on the thorax. The adult beetles eat the leaves of orchard trees and also damage fruit; the females lay their eggs in garden soil, and plentifully in grass land; and the grubs which hatch gnaw the roots through, and the plants die off. In hill-pastures much harm is done sometimes by these grubs, strips of pasture looking as if they had been burned, owing to the withering away of the above-ground parts on account of the destruction of the roots. Parts of golf links have been destroyed in the same way.

In working against this enemy the beetles should be shaken down, in the early morning, off the plants on which they are settled, on to cloths spread for the purpose, and then collected. The grubs are not easy to reach. Birds are, in cases of infestation, most useful—crows, starlings, plovers, pheasants; the common hen takes the grubs greedily if it gets the chance.

Corn Ground-beetle (*Zabrus gibbus*). —The ground-beetles are mostly useful, being carnivorous in diet (see Useful Insects, p. 469), but this beetle is harmful to cereals, both in the adult and in the larval stages; the adults have been found crawling up the stems and destroying the grain; the grubs destroy the plants at or near the surface. The beetle is half an inch long and black in colour, with a dash of purple; legs and antennæ are brown. The grubs are pale-brown; their head is large, and carries a pair of strong sickle-shaped jaws; they are active, moving about by means of six thoracic legs; in common with the ground-beetle larvæ they have two projections at the tail end, with a smaller one between.

Corn and Rice Weevil.—The corn weevil (*Calandra granaria*) (fig. 647) and the rice weevil (*C. oryzæ*) are both very troublesome to stored grain—wheat, barley, oats, and the rice weevil to rice, and also to cargoes in ships. *C. granaria* is ⅛ of an inch long, and has the long beak characteristic of weevils; the colour is brown-black; the antennæ, which spring from the beak, are reddish in colour and bent; the legs are also red; the wing covers are striated; the beetle is wingless. *C. oryzæ*, which has wings, is smaller, smoother, paler, and has two orange-coloured patches at the apex and base of the wing-covers.

1 2

Fig. 647.—Corn Weevil (*Calandra granaria*).
1. Beetle, magnified. 2. Infested wheat grain.

The beetles lay their eggs—an egg to a grain—in a hole made in the grain, and the larva on hatching feeds on the contents of the grain, and when full fed

pupates in the spoilt and hollowed-out grain, the mature weevil issuing in due course. The adult beetle, too, is harmful by puncturing and feeding off the grain. The length of the cycle from the laying of the egg to the development and appearance of the adult beetle varies much with the conditions. At a temperature of 80° Fahr., and with the other conditions favourable, the whole life-cycle can be completed in a month. The adult beetles have a long life.

Treatment.—Infested grain from cargoes is run through a sieve or down a screen whose mesh-work is fine enough to keep the grains back and yet let the beetles pass through, these being caught in a vessel containing paraffin arranged below for the purpose.

The best method to rid the grain of the pests is fumigation, the fumigant being bisulphide of carbon. This liquid vaporises readily, and the vapour being heavier than air sinks or falls. Place the grain to be treated in a bin or air-tight receptacle, pour into a saucer or shallow vessel some bisulphide of carbon, and then lay the saucer *on the top* of the grain. Close the receptacle tightly, and leave for from twenty-four to forty-eight hours. The fumes kill all the insects. Two pounds of bisulphide of carbon are sufficient to fumigate one ton of grain. Bisulphide of carbon has a disagreeable odour, and as the fumes are poisonous they should not be breathed more than is necessary by human beings. A naked light must not be brought near the fumes, else an explosion takes place.

The most favourable environment for the development of these grain weevils in cargo is heat, a certain amount of moisture, and a confined atmosphere.

Flour Beetles.—Two little beetles (*Tribolium confusum* and *T. ferrugineum*) are sometimes very troublesome in flour. *T. confusum* is reddish-brown in colour, and measures about 1/8 inch in length; the joints of the antennæ get larger towards the apex. *T. ferrugineum* is very like *confusum* in colour and size, but the antennæ end is a distinct three-jointed club.

The beetles lay their eggs on and in the neighbourhood of the flour, meal, or other cereal product. The small six-legged hairy grubs which hatch may be found crawling about amongst the material. In a favourable temperature there can be a number of broods in a year, so that infested material can quickly get worse. In addition to the presence of the pests in the flour, the sample gives off a disagreeable odour.

Treatment.—Fumigate with bisulphide of carbon (see p. 445), five ounces of bisulphide of carbon to a barrel of flour. The flour after fumigation and before being used should be exposed to the air.

Corn Thrips (*Thrips cerealium*).—The insect is 1/12 inch long. The male is wingless; the female has four wings; eggs are laid in the ears of cereals; the larvæ which develop are deep yellow. The result of attack is a shrivelling of the grain.

When at work in the ears the insect cannot be reached, but hibernation takes place in the stubble, and in decaying roots deep ploughing would destroy many.

The Order Thripidæ.

This is a family of elongated insects with four long narrow wings that have long fringes. As regards metamorphosis, the thrip insects make a connecting link between complete metamorphosis and the absence of a resting stage. From the egg hatches a young form which feeds for a varying length of time. Then follows a non-feeding stage, when the full-grown larva is sluggish, the rudiments of the wings being encased in a sheath and the limbs hidden by a film. The next is the mature stage. The mouth-parts are modified for piercing and sucking. The legs have a small bladder or sucker at the tip of each tarsus.

Hops.

Hop Aphis (*Phorodon humuli*).—This aphis (fig. 648) is the worst enemy of the hop, its damage being in some years very great. The hop aphis appears upon the hop plants generally about June, and if the conditions of temperature and of the plants are favourable, it multiplies with astonishing rapidity. The swarms live upon the sap of the plants, which is drained away by the long, piercing and sucking beak of the insect.

They attack first the youngest and smallest leaves of the leading shoots, which are more succulent than the older leaves. After a week or two the growth of the plants is checked, and the plants struggle in vain to reach the top of the poles. Their juices are exhausted by the continuous suckings of the insects; the respiratory and sugar-making and transpiring functions of the leaves are interfered with by the honey dew — a peculiar glutinous sweet secretion ejected from the bodies of the aphides—falling on their upper surface, and by the aphides congregating and feeding on the lower surface. In three weeks to a month after the appearance of the aphides—if these are in number—the plants shrivel, the leaves turn black and fall off, and all chances of a crop are lost. If the numbers have not been overwhelming and the plants survive, the aphides may go into the hop cones, which, as a result, are deteriorated in value.

There are two possible cycles in the life-history. The wingless females that may have hibernated pass to the plants in the spring, and by these living young are produced. This mode of multiplication continues during the season. In the course of the summer winged females appear, and, flying to other hop plants, spread the infection. As the season ends males appear for the first time in the year's life-cycle, and the females after fertilisation hibernate.

The alternative life-cycle is: The fertilised females desert the hop and fly to sloe and damson and plum, and on the shoots of these lay their eggs. These eggs hatch in the next spring, and the young develop into winged females, which migrate to the hop from May onwards.

Treatment. — (1) Spray the plants with soft-soap and quassia (see p. 444). (2) The plum and the damson should be washed in winter, to destroy the eggs laid on them.

Winter Washing of Fruit-trees.

The advantage of the winter washing of fruit-trees is that mosses and lichens and such vegetable growths that cover the bark are removed. These provide shelter and hibernating places for a number of injurious insects, which are destroyed by the wash; eggs also, which would hatch in the next year, are destroyed. In Leaflet No. 70 of the Board of Agriculture full details are given, and the Woburn Winter Wash quoted.[1] Mr Pickering has suggested the following modification: Sulphate of iron, ½ lb.; lime, ¼ lb.; caustic soda, 2 lb.; paraffin (solar distillate), 5 pints; water to make 10 gallons.

Dissolve the iron-sulphate in about 9 gallons of water. Slake the lime in a little water, and then add a little more water to make it into a milk; run this into the first through a piece of coarse sacking, to keep back grit. Next, churn

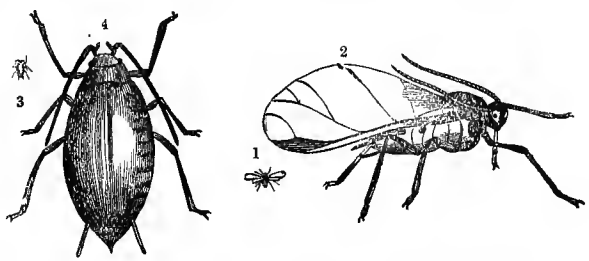


Fig. 648.—Hop Aphis; Green Fly (*Phorodon humuli*, Schrank).
1 and 2, Female aphis, natural size and magnified; 3 and 4, Larvæ, natural size and magnified.

the paraffin into the mixture and stir. Just before using add the caustic soda in the powdered condition.

It should be noted that this wash is a burning one, and the hands and face of the worker require protection during its use. February would be a suitable month for the treatment. The principle is that this wash, with its caustic properties, may only be used when the plant is in a dormant condition.

Natural Enemies of the Hop Aphis. —Many aphides are devoured by the larva of the lady-bird and by the larva of the lace-wing fly; others are parasitised by the chalcid flies (see p. 469).

The Hop Frog-fly (*Euacanthus interruptus*) is now and again found troublesome. The insect (fig. 649) in the adult

[1] *Eighth Report of the Woburn Experimental Fruit Farm.* 1908. By The Duke of Bedford and Spencer U. Pickering.

stage can fly, and is also capable of making long jumps. In the case recorded by the late Miss Ormerod, the insect was found "principally infesting the tops and therefore most succulent portions of the bines; when once the plant becomes a prey to them, it is visibly checked in

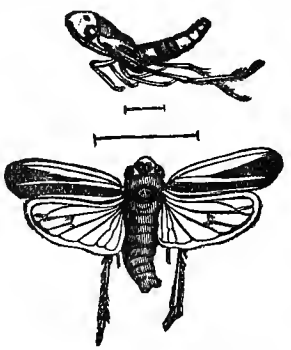


Fig. 649.—Hop Frog-fly (*Euacanthus interruptus*, Linn.)

growth, the leaves assume a deformed shape, and curl at the edges." The only measure so far attended with success is to jar the insects off the plants on to tarred boards or sacking.

Fever-fly (*Dilophus febrilis*).—This black fly, which sometimes appears in swarms, has been blamed as an enemy to the hops, the larvæ being accused of spoiling the roots: the larvæ are also found in cow and horse manure, and it is possible that in this way they may be conveyed to plants.

The Hop-flea or Brassy-flea Beetle (*Phyllotreta concinna*). — This tiny beetle measures only between 1½ and 2 millimetres; yet, after the hop aphis, it is the worst enemy of the hop. It is oval in shape, and greenish in colour, with a brassy tint. The beetles are excellent jumpers. The harm is done both by the adult beetle and the grub. The beetles bite holes in the leaves and shoots when these are quite young, and when in numbers ruin the plants. The eggs are laid by the beetles on the under side of the leaves, and the grubs on hatching bore into the leaf, which they proceed to mine. The full-fed grub—the growth is completed in 7 or 8 days—falls to the ground, and in the soil the pupation stage is passed. There are several broods in the year.

Treatment. — The beetles should be jarred off the plants on to tarred boards or sacking (see Turnip-fly, p. 463).

Mr Fred. V. Theobald[1] has described the hop cone-flea (*Phyllotreta attenuata*). It is about the same size as the last, and is deep shiny green, with the wing-covers slightly hairy at the apex. Mr Theobald finds that its damage is done not in spring but late in the year. The harm in the late part of the year lies in the attack on the cones, the beetles "riddling the bracts until the crop is spoiled." The eggs may also be laid in the cones, the grubs mining in the bracts.

Spiders.

Hop Red-Spider (*Tetranychus*). — Red-spiders are not insects, but belong to the Mite section of the class Arachnida or Spinners. They can be told from insects by the absence of the marked division into head, thorax, and abdomen, and by the adults having 8 legs and not 6 (fig. 650). The red-spiders spin webs on the under surfaces of the leaves; here eggs are laid, from which hatch small 6-legged forms, which feed and moult, attaining with their last moult a fourth pair of legs. All stages of the mite from egg to adult may be found in the webs. In hot dry weather multiplication is very rapid, and the web-covered leaves, deprived of their sap, become sickly and yellow, and wither. Hibernation of the mites takes place in cracks in the hop-poles and in other shelter places.

Fig. 650.—Red-Spider (*Tetranychus telarius*, Linn.)

Treatment. — The pests are difficult to fight when their numbers are great, and when their webs have been formed in mass. Early treatment then should be practised, this consisting of spraying with paraffin emulsion (see p. 444), to which it is advisable to add 2½ lb. of liver of sulphur (sulphide of potassium) for every 100 gallons of the wash.

[1] *Notes on Economic Zoology*, p. 14. By Fred. V. Theobald, M.A.

The Onion-fly (Phorbia cepetorum).

This fly (fig. 651) measures ¼ to ⅓ of an inch. The colour is grey, the males being distinguished by having a dark line down their back; the compound eyes of the male, too, are closer together than they are in the female, a sexual distinction very common in the Diptera. The wings are iridescent, and have brown veins. The maggots, which are the direct cause of the damage, are legless, smooth, and fleshy, with a pointed head, provided with two rasping hooks, and a blunt posterior end, in the centre of which are two brown spiracles, while round the margin of this hind segment are a number of little projections. The puparium is oval and red-brown.

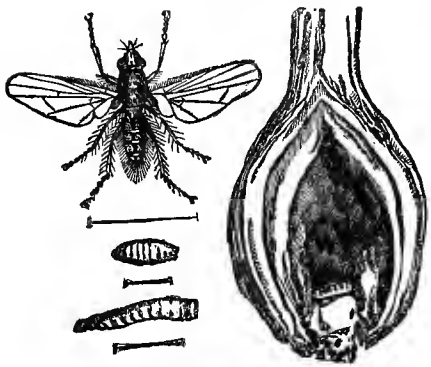


Fig. 651.—Onion-fly (*Phorbia cepetorum*, Meade).

The signs of infestation are a yellowing and drooping of the leaves, slimy decaying misshapen bulbs in which the maggots will be found at work, or the red-brown puparia. In April and May the flies proceed to lay their oval white eggs close to the leaves at the surface of the ground, or on the neck of the plant—6 to 8 eggs on each plant. The maggots on hatching descend between the leaves into the bulb. Here the maggot feeds for a fortnight before pupating, and in 10 to 20 days from the puparia being formed the new brood of flies may come away. There are several broods in the year, the first flies of the year being seen in April, and the last ones as late as November in an open season.

Treatment.—As a deterrent to egg-laying, the young plants should be sprayed with paraffin emulsion (see p. 444), this spray to be repeated three times, at intervals. Another protective measure is to sprinkle sand mixed with paraffin-oil—a cupful of paraffin-oil to a pailful of sand—at the base of the onion plants. Earthing up the onions to the neck and broadcasting soot over them is a good measure. All infested plants should be carefully removed and destroyed before the maggots have had time to develop themselves: in this removal pieces of attacked bulb should not be left behind.

A stimulating dressing of nitrate of soda, 1½ to 2 cwt. per acre, on infested land may help the plant in resisting the attack. A plan practised in the United States and quoted by Smith is, "Keep a close look-out for the first sign of the maggot. Turn away the earth from the rows with a hand-plough so as to expose the root-system in part, then apply broadcast 600 lb. kainit and 200 lb. nitrate of soda per acre; turn back the earth to the plants, and this will stop the injury. The application is best made just before or during a rain, or immediately after a good shower. The object is to get the salty fertilisers dissolved rapidly and brought into direct contact with the roots of the plant, and, of course, with the insects as well. This plan has proved entirely satisfactory on light lands, but it has not been tested on heavy land."

Onions should not be taken on the same land in the year following an attack.

Parsnip-fly (*Acidia heraclei*). (See p. 449.)

Peas.

The Pea Beetle (*Bruchus pisi*). (See p. 445.)

Pea and Bean Weevils.—The pea and bean weevils (*Sitones lineatus* and *Sitones crinitus*) (fig. 652) are harmful—the first especially—in the adult and in the larval stages, the adults eating pieces out of the leaves of young plants and the grubs feeding on the roots. The attack is known by the leaves being scooped out at the edge. The beetles begin their ravages at the outside of the leaves, and often eat all except the central rib. The striped pea weevil (*Sitones lineatus*)

is of an ochreous or light clay colour, the antennæ and legs are reddish; it measures up to ¼ inch long. The spotted pea weevil (*Sitones crinitus*) is rather smaller and more of a grey colour; the wing-cases have short bristly hairs down the furrows, and are spotted with black.

The grubs have been found, by the observations made in the last few years, to feed at the roots of peas and clover and other leguminous plants, and may be found in large numbers at clover roots during the winter. The weevils until lately were supposed to feed by day, and shelter themselves in the ground under clots or rubbish at night, but more recently they have been observed to be night-feeders also.

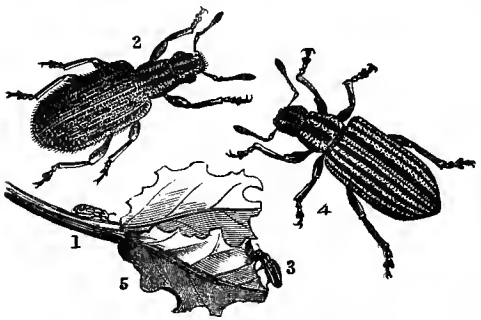


Fig. 652.—Pea and Bean Weevils (*Sitones lineatus*, Linn.; *Sitones crinitus*, Olivier).

1 and 2, *S. crinitus*, natural size and magnified; 3 and 4, *S. lineatus*, natural size and magnified; 5, Leaf notched by weevils.

The weevils come from their winter quarters in spring, and in May lay their eggs on and under the soil beside their food-plants. The grubs are white and fleshy, with brown heads and gnawing jaws. A second brood of beetles may develop from these by July. Hibernation may be in the adult in the larval stage. In a communication received from Yorkshire last October, we were told that "beans standing in the field in stooks are covered with countless thousands of Sitones, which cause a rattling sound, as one walks through the lines of stooks, by their falling and feigning death. They are eating through the bean pods and attacking the beans themselves, but only those with green pods apparently. The adjoining field is young clover (oat stubble), and this the Sitones are now attacking—hardly a clover leaf being free from attack, and many Sitones clearly visible at their work." When the weevils fall to the ground on the plants being touched, and lie motionless, feigning death, they are very difficult to see.

Treatment.—As pea crops suffer most from weevil attacks in the early stages of their growth, it is most important that the soil should be well pulverised, and an available supply of manure given to push on the growth of the plant. Dressings of lime and soot (applied when the peas are wet) are good. Starlings and insectivorous birds are very fond of these weevils.

Care should be taken to have the weevils swept out from the bottom of waggons and carts when the crop is being carted home, and also to remove them from the platforms of the threshers. The collected beetles can be destroyed by dropping them into paraffin or into boiling water.

Pea Moth (*Grapholitha pisana*). —The caterpillar of this little moth hatches from the egg laid in the pea blossom; it eats through the young pod and into the seed. The caterpillar has 16 legs, measures about ½ an inch long, and is pale-green in colour, the head and joint behind the head being brown; tubercles and hairs show here and there. This larva, on being full fed, leaves the pea and enters the soil where a cocoon is made, inside which the caterpillar, after sheltering for the winter, passes on to pupation stage.

Treatment.—The peas should not be left, without being harvested, long enough for the caterpillars to complete their growth. If the surface-soil of an infested area be buried deeply the moths from cocoons so buried will not appear in the next season.

Pea Midge (*Diplosis pisi*).—The maggots of this midge, present sometimes in large numbers in the pea-pods, cause malformation of the pod, and may spoil the crop. A number of attacked pea plants reached us in the beginning of August 1906, and in the accompanying letter it was stated, "As far as outward appearances go I never saw a more

robust lot of plants; but I noticed that the blooms did not open properly, and some not at all, and now my crop is being ruined." Many maggots—whose springing habit was noticeable—and pupæ were found in the material. Deep ploughing was recommended, and the clearing away of attacked plants and burning them after the collection of the pods. Mr Fred. V. Theobald recorded the fly in his *Report on Economic Entomology*, 1906, and described it in his report for 1907. The larvæ measure 3 mm., and are yellowish in colour, with a marked anchor process: when full grown they reach the soil by the opening of the pods.

Pea Thrips (*Thrips pisivora*).—This insect attacks the blossom of pea and scarlet-runner beans, spoiling the flowers by their feeding, so that the pods are misshapen or may fail. Mr Theobald, in his *Report on Economic Zoology* for 1906, pp. 84 and 85, describes an attack on the pods of the pea thus: "The adults laid their eggs on the growing pods. The little yellow thrips collected in groups on the outside of the pods, and in one case ruined several rows of garden peas. The damage was very noticeable, even in the beginning of the attack. The tenderer pods were soon contracted and deformed, slightly older ones ceased to grow and remained thin, and no peas were produced. At first the skin around the attacked areas became of a silvery hue, then brown rusty patches appeared, and by degrees the pods, even those nearly mature and ready to pick, dropped off."

The female thrips, which has the characteristically fringed wings (see p. 456), is very small, measuring $^1/_{16}$ to $^1/_{12}$ inch, and in colour is black-brown, with pale bands on the abdomen; the larvæ from the eggs are orange-yellow in colour.

Treatment.—In the case just quoted from Mr Theobald's report successful results were got from two different sprays—viz., 1 ounce pyrethrum powder and 1 ounce soft-soap, in 2 gallons of water; or boil 6 ounces of coarse tobacco in 2 gallons of water with 2 ounces of soft-soap.

To reduce attack in the next year, it is recommended that the old sticks used for the peas and beans and the haulms which are used as places of hibernation by the adult strips should be burned.

Potatoes.

The Colorado Beetle (*Doryphoru decemlineata*). — This beetle (fig. 653), which had done much damage in the United States to potatoes, was found at Liverpool in 1877. The possibility of its becoming acclimatised in this country led, in view of its bad record in the United States, to the Colorado Beetle Order, 1877, legislation extended by the passing of "The Destructive Insects and Pests Order, 1908," an order which gives greater powers to the Board of Agriculture. Its native food-plant was a wild Solanaceous plant, but about 1850 it was found feeding on the potato-

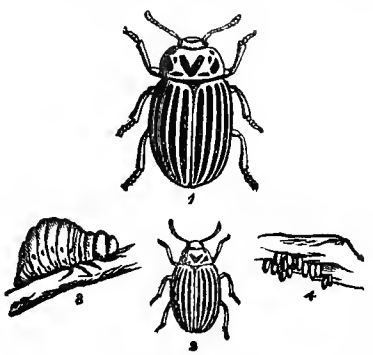


Fig. 653.—Colorado Beetle (*Doryphoru decemlincata*, Say).

patches of early settlers in the West United States. Gradually it spread east, until by 1874 it had reached the Atlantic coast. It has since been recorded from the continent of Europe; and, as mentioned above, it appeared in England in 1877; it appeared again in 1901 and 1902 at Tilbury Docks. Exterminative measures applied rigorously at this time were successful.

The Colorado beetle measures about ½ inch in length; it is oval in shape, robust in build, and yellowish or cream coloured, with five longitudinal black lines down each wing-cover. The oval orange-coloured eggs are conspicuous when seen fixed to the leaves of the potato. The larva is a six-legged grub, red-brown in colour, with the head and

the legs black, and two rows of black spots on each side: the body is arched,

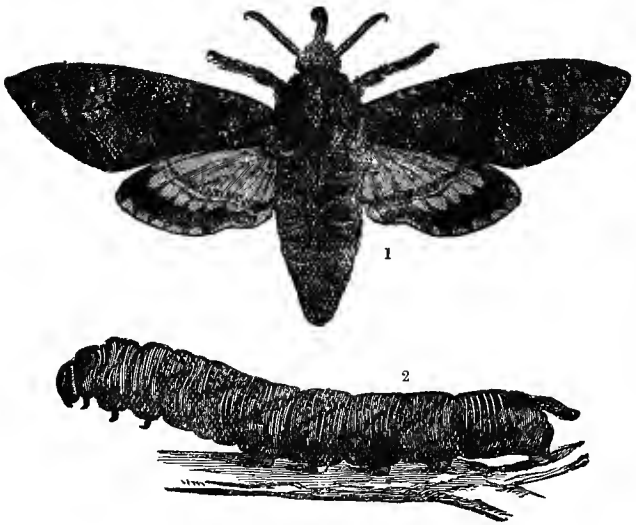


Fig. 654.—Death's-head Moth (*Acherontia atropos*).
1, Moth; 2, Caterpillar.

giving the grub a humpbacked appearance. The full-grown larva enters the soil for pupation.

In the United States the Colorado beetle was greatly feared as long as the only practised treatment was hand-picking, but since the introduction of arsenical sprays the insect is not considered to have its old importance, control being so much easier.

The Death's-head Moth (*Acherontia atropos*). — This is the largest of the British moths (fig. 654). Its caterpillar is sometimes found feeding on potato-leaves. It usually feeds by night; and when it is noticed as doing great damage, it is advisable to resort to hand-picking in the twilight or by moonlight.

Turnips.

The Turnip Mud-beetle (*Helophorus rugosus*).—Although this beetle (fig. 655) has a wide distribution in Britain, yet complaints of damage by it are practically limited to Aberdeenshire. The leaves may be eaten; the leaf-stalks may be tunnelled; the root tubers may be gnawed and tunnelled on the outer surface. The curled-up leaves draw attention to the attack. The crown of the tuber is a favourite place for the pests, which, sheltered in the leaf bases, destroy the young leaves. Both adult beetle and grub are destructive, and the worst damage is done when the plants are small. The beetle measures ¼ inch in length; it is dark-red in colour, but the redness is often obscured by mud; the thorax is ridged and knobbed; the wing-covers have longitudinal ridges, between which are rows of punctures. The grub is six-legged; the head is dark coloured and the jaws brown; a transverse curved line marks the upper surface of the three thoracic segments; down the back there are two rows of square spots and smaller spots at the sides; the body ends in two processes.

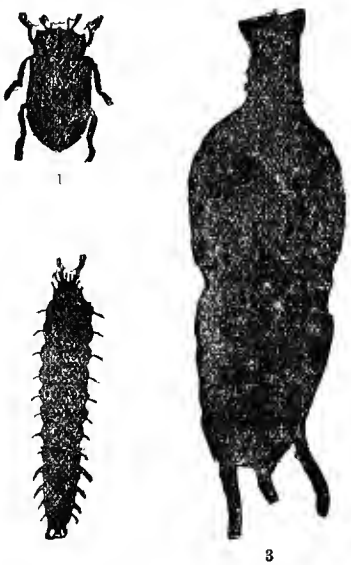


Fig. 655.—The Turnip Mud-beetle.
1, Beetle, magnified; 2, Larva, magnified; 3, Turnip showing gnawings of grub.

The complete life-history is not known, and so far treatment has been confined to helping the plants by stimulating dressings.

The Turnip and Cabbage Gall-weevil (*Ceuthorhynchus sulcicollis*).—This weevil is ⅛ inch long, and is dull-black in colour, with greyish scales which show in fresh specimens; a proboscis or beak is present from which the bent antennæ spring. The eggs may be laid on or in the root of turnip or cabbage. The grubs are yellowish-white, with brown heads and gnawing jaws; they are legless, and their body is wrinkled. From their irritating presence galls form on the roots, and inside these the feeding grubs are found. Pupation takes place in the soil under cover of a small earthen cocoon. Such cruciferous weeds as charlock act as breeding and feeding places for the weevil early in the year, and later on the turnip is attacked. Infested plants should be removed early. The cabbage stocks and removed plants should be burned, as, if merely left to die or thrown into a heap, the insects may complete their development; badly infested turnips could be fed off by stock, and then deep ploughing should follow.

C. assimilis, a smaller dark-grey species, is harmful as adult in the flower-heads of various crucifers—*e.g.*, turnip, mustard, rape; while the grubs feed on, and destroy, the seeds in the pods. Harvested seed containing the larvæ or pupæ should be fumigated with bisulphide of carbon (see p. 445).

A third species, *C. contractus*, is a troublesome enemy to young turnip and mustard. This beetle is smaller than the two preceding species, measuring only up to $^1/_{16}$ inch; it is shining black in colour, and has a slender proboscis; if examined with a lens the front part of its body is seen to be deeply grooved. Attack may be on the leaves above ground, or in the stem above ground, or on the seed-leaves just above ground, or the newly sprouted seedling may be attacked and destroyed before the plant reaches the surface. Mr R. B. Greig pointed out, in the *Journal of the Board of Agriculture* for April 1905, that the seed-leaves were attacked just as they emerged from the seed, and showed light-brown spots sometimes ascribed to frost or the turnip-fly. Mr Greig, along with Professor Trail, made a series of observations on this weevil, and they found that the insect is kept off if the seed be steeped for an hour or two in paraffin before sowing.

The Flea-beetles (*Halticæ*).—This family of Leaf-beetles is characterised by a leaping habit, hence the name flea-beetles; the femora of their hind-legs are much thickened: Mr Fred. V. Theobald has been at much pains to make clear that the most harmful forms belong to the genera *Phyllotreta*, *Haltica*, *Psylliodes*, and in his *Notes on Eco-*

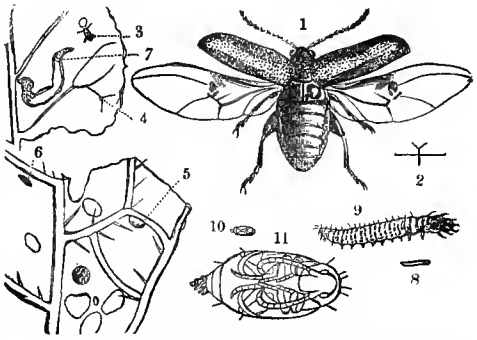


Fig. 656.—Turnip-fly (*Phyllotreta nemorum*, Chevrolat). 1–3, *H. nemorum*; 4 and 5, Eggs; 6–9, Maggot; 10 and 11, Pupa: all natural size and magnified.

nomic Zoology has given a full and extremely useful description of the various species of economic importance.

Turnip-fly or Flea-beetle (*Phyllotreta nemorum*).—This (fig. 656) is a small shining beetle, measuring from $^1/_{12}$ to ⅛ of an inch. It is black, blue-black, or green-black, and has a yellow longitudinal stripe down each wing-cover. The adult beetles come out of their winter quarters in spring, and lay their eggs, and feed on charlock and such other wild crucifers as Jack-by-the-hedge and shepherd's purse. The grubs feed internally, mining in the soft tissue of the leaf. When full grown they drop to the ground, pass into the soil, and there pupate. The whole life-cycle, from egg to adult, may be completed in a month; hence there may be several generations

in a year. The adult beetles especially are harmful from their destruction of the seed-leaves, but they also feed on the rough leaves.

Phyllotreta nemorum is one of a large number of related species—*e.g.*, *P. consobrina* and *P. undulata* and *Haltica oleracea*; and in his exhaustive paper in the *Notes on Economic Zoology* mentioned above, Mr Theobald notes this most practical point, that in the genus *Phyllotreta* the larva feeds internally, and that, therefore, treatment has to be directed chiefly against the adult, whereas in the genus *Haltica* the eggs are laid on the outside of the food-plant, and the larvæ on hatching continue to feed externally, so that the *Haltica* species can be fought both in the larval and adult stages.

Treatment.—As the fly will appear before turnips are sown, it is most important to clear away charlock and other weeds suitable for its food.

One spring, a field in good tilth, ready for turnips, suddenly became a mass of charlock. This was entirely cleared away by the fly, which again appeared and preyed on the turnips when sown. Had the precaution of harrowing up the charlock as soon as it appeared been taken, the turnips would in all probability have been saved.

In coping with the turnip-fly the following important principles should be observed: 1st, cleaning the ground; 2nd, destroying rubbish round the fields which might serve as shelters to the flea-beetles; 3rd, so preparing the ground by good cultivation and plenty of manure that the growth of the turnips may be pushed on vigorously past the first leaves, in which stage they are most vulnerable to the attack of the fly: where it is possible, autumn cultivation is desirable, so that at turnip-sowing the upper surface will only require slight disturbance, and thus the moisture beneath, which is a great desideratum for the young turnips, will remain to aid the growth.

As a deterrent to the fly, the seeds should be steeped before sowing in paraffin or turpentine, and the young plants might be sprayed with paraffin put on by a Strawsoniser (fig. 622), by which one gallon of paraffin to the acre can be distributed.

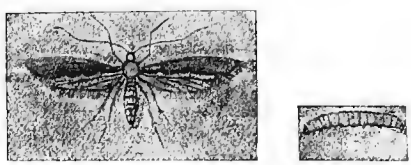
Mr Fisher Hobbs's remedy for the fly was as follows:—

"1 bushel of white gas-ashes" (gas-lime) "fresh from the gas-house, 1 bushel of fresh lime from the kiln, 6 lb. of sulphur, and 10 lb. of soot, well mixed together and got to as fine a powder as possible, so that it may adhere to the young plant. The above is sufficient for two acres, when drilled at 27 inches. It should be applied very early in the morning *when the dew is on the leaf*, a broadcast machine being the most expeditious mode of distributing it; or it may be sprinkled with the hand carefully over the rows."

Boards tarred on the under surface, placed on wheels and run through the fields, will trap many of the beetles, as these in leaping stick to the tar.

In order to poison the larvæ and the feeding beetles, the plants should be sprayed with an arsenical spray put on with a Strawsoniser.

The Diamond-back Moth (*Plutella maculipennis*).—The caterpillars of this moth (fig. 657) are harmful to cruciferous crops generally. The insect, while



1 2

Fig. 657.—Diamond-back Moth.
1, The moth, magnified; 2, The caterpillar of the moth.

not markedly prevalent every year, now and again, when circumstances favour it, works great havoc. In favourable conditions for the moth there are two and more broods in the year. The front wings of the moth are grey-brown with dark markings, with a whitish waved stripe along the hind margin of each: when the moth is at rest and the wings lying on the back the two hind edges of the front wings meet, and the wavy stripes give the appearance of diamond-shaped areas, hence the common name of the moth. The hind wings are pale ash-grey, and are fringed. When the moth is at rest the wings are somewhat tilted up at the ends. From the yellow-white head the antennæ project straight

forwards. The caterpillar is faint-green in colour, with a darker head; it has 16 legs, measures about ½ an inch when full grown, and tapers to both ends. A light cocoon is spun on the leaf by the full-fed caterpillar.

Treatment.—Apart from the destruction of crucifer weeds, so that the food-plants on which the earliest moths of the year can lay are lessened, the remedial measures are directed against the caterpillars.

To dislodge the caterpillars drag furze or other branches across the turnips, taking care that the under sides of the leaves are reached, then follow with the scuffler so as to bury the fallen caterpillars. Dress the plants with a mixture of soot and lime in the proportion of 1 part of lime to 3 of soot. Spray with paraffin emulsion (p. 444).

The caterpillars are poisoned if the leafage be sprayed with arsenate of lead. This can now be bought in the paste form as Swift's Arsenate of Lead from Strawson's, Queen Victoria Street, London. The proportions recommended are 2 lb. thoroughly mixed up in 50 gallons of water.

Surface Caterpillars.

These are also known as "cut-worms," from their biting the stems through. The name is applied to such caterpillars as hide below the surface of the soil and attack plants, generally at night, at or just below the surface. Three very troublesome surface caterpillars are those of the turnip moth (*Agrotis segetum*) (fig. 658), the heart-and-dart moth (*Agrotis exclamationis*), and the yellow underwing moth (*Tryphœna pronuba*). Turnips, swedes, potatoes, mangolds, carrot, lettuce, wheat, grass, and many other field and garden plants are injured by these caterpillars.

The yellow underwing caterpillars are 1¾ inch long when full grown; the head is ochreous, and has two black stripes; there is considerable variation in shade of colour, greenish-brown being the prevailing tint, with a line down the back, and black spots or streaks along each side; the colour below is pale green.

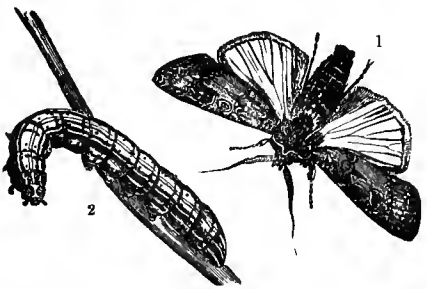


Fig. 658.—Turnip Moth (*Agrotis segetum*, Westwood). 1, Moth; 2, Caterpillar.

On being disturbed the caterpillars coil themselves into a ring.

The caterpillar of the turnip moth and of the heart-and-dart moth may be contrasted thus:—

Heart-and-Dart Moth.	Turnip Moth.
About 1½ inch long, brownish in colour; spiracles black, and larger than the spots before and behind them.	When full grown about 1½ inch long, greyish in colour.
A pear-shaped blotch on the first 5 segments.	No pear-shaped blotches.

The caterpillars of the above three moths may pass the winter in the larval stage, renewing their feeding in the next spring.

The pupæ are red-brown.

Treatment.—If the attack be on a small scale the caterpillars may be hand-picked; the worker provided with a lantern makes a round of the plants, and turns up the cut-worms by means of a blunt knife or a pointed piece of wood.

Disturbance and destruction of the caterpillars by horse and hand hoes; caterpillars or pupæ are killed or brought up for the birds.

In America there are records of successful treatment by poisoning the caterpillars. This may be done by spraying clover or grass with Paris-green—1 lb. of Paris-green to 50 gallons of water, the mixture to be kept well stirred,—afterwards tying these sprayed plants into bundles and distributing them at intervals through the crop.

The Turnip Sawfly (Athalia spinarum).

The damage done by the larvæ of this sawfly (fig. 659) may be very great, partly because of their numbers and their voracity and the rapid succession of broods. The caterpillars are known as "blacks," "black palmers," "niggers," &c. They will sometimes clear off the leafage of a whole field. The figure will give an idea of their destructiveness.

Fig. 659.—Turnip Sawfly grub at work.

One sawfly (fig. 660) will lay from 200 to 300 eggs, and these will hatch in five days, or less in warm weather. The larva is a caterpillar with 22 legs; it is greenish-white at first, but at last it is black; full grown it measures ¾ inch. When full grown, in about three weeks the larvæ go down to the earth and spin a silken cocoon; from these cocoons the sawflies emerge in about three weeks. It should be remembered that, when they are moulting (that is, every six or seven days during the time they continue in the grub form), if they are disturbed they die; for if they lose hold with the pair of feet at the tip of the tail during the operation, they cannot fix themselves so as to pull themselves out of the old skin, and therefore they perish in it.

Prevention.—In order to effect dislodgment of the caterpillars a very light bush harrow should be drawn over the turnip leaves. Spray the plants with arsenate of lead (see p. 465). A field that has been badly infested should be deeply ploughed to bury cocoons.

Spring-tails or Collembola.

These small wingless insects live in concealed places, under stones, bark, moss, and in damp soil. They feed on decaying organic matter; but evidence is accumulating to show that they are capable of doing damage, first hand, bean seeds and seedling turnips and cabbages being mentioned in the literature as suffering. Their respiration is typically through the skin, tracheæ being wanting, and therefore moisture is a necessity. Dressings of lime or of soot and lime are effective against them.

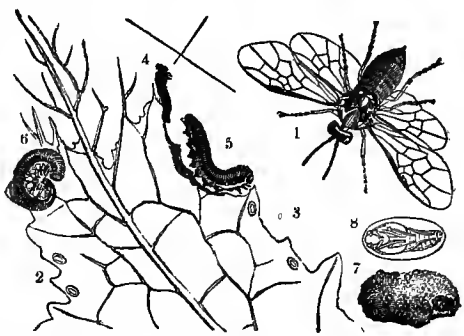


Fig. 660.—Turnip Sawfly (*Athalia spinarum*, Fabricius). Caterpillars, pupa, and pupa-case; Sawfly, magnified, with lines showing natural size.

FRUIT.

In view of the development which has taken place in fruit-growing, some notes are added on the insects which attack raspberry, strawberry, gooseberry, and black currant.

Raspberries.

Raspberry Weevils.—The clay-coloured weevil (*Otiorrhynchus picipes*) and the red-legged weevil (*O. tenebricosus*) are destructive not only to raspberry but also to a number of other fruit plants.

Harm is done both by adult weevil and grub, the grubs living in the soil and destroying the roots, the weevils feeding on above-ground parts. The clay-coloured weevil measures ¼ inch in length, and the red-legged weevil up to ½ an inch. These weevils feed at night and shelter in the day-time; they cannot fly. The grubs are yellow-white in colour, and have brown heads and biting jaws.

Treatment.—Shake the beetles, at night, down off the plants on to sheets or tarred boards. They may also be trapped by twining bands of hay among the plants, for the weevils will use these to shelter in during the day-time.

Raspberry Beetle (*Byturus tomentosus*).—This is a small but very harmful bettle, measuring ⅛ inch in length; it is brown in colour, and, examined with a lens, is seen to be covered with a greyish-yellow pubescence. The full-grown grubs reach about ¼ inch in length; they have biting jaws, 6 legs on the thorax, and 2 processes at the hind end, with a smaller projection between them. The beetles appear about the middle of May, and lay their eggs in the blossom; the grubs on hatching pass into the fruit. When full fed, towards the end of the season, the grubs leave the fruit and pupate under cover of a cocoon in the soil below the plants or in cracks in the bark.

Treatment.—Shake the beetles off the plants on to tarred boards or into a vessel containing paraffin. Burn prunings and old canes likely to be used as places for the pupation stage. Bury the surface-soil with the cocoons.

Raspberry Moth (*Lampronia rubiella*).—The caterpillars of this moth are very harmful to the raspberry canes. The life of the caterpillar extends into two seasons; in the first year the caterpillars, which come from eggs laid in the blossom, do not complete their growth but leave the plants and enter the soil for wintering; in the next spring the caterpillars climb up the plants, bore into the buds, and tunnel the shoot below the buds; in this hollowed shoot they pupate. The full-grown caterpillar measures ¼ of an inch; it has 16 legs, and is red in colour, with the head black, and a black patch on the joint behind the head.

Treatment.—Cut off and burn infested canes while the caterpillars or pupæ are present; this can be done from the end of April till the middle of May. The over-wintering caterpillars should be disturbed in their shelter-places by the surface-soil being buried. If the bases of the canes be coated in March with a sticky composition, the caterpillars in coming from their hibernating quarters will be prevented from ascending the canes.

Strawberries.

The Black Vine Weevil (*Otiorrhynchus sulcatus*).—This is a close ally of the two weevils mentioned under raspberry, and is an enemy of the strawberry. The adult weevils gnaw the runners and the shoots, and their grubs attack the roots and crown of the plant. The beetles are found in summer when egg-laying takes place; the grub stage lasts over the winter till the next spring, when pupation takes place.

For treatment reference should be made to the raspberry weevils.

Ground-Beetles (*Carabidæ*).—The ground-beetles as a family are useful, being predaceous both as adult and larva; but there are several species which as adult have often proved most destructive to the strawberry fruit.

The beetles are: *Pterostichus* (*Omaseus*) *vulgaris*, a shining black beetle, with two longitudional depressions on the thorax and with striated elytra; there are no flying wings; it measures 6½ to 7½ lines in length; *Pterostichus* (*Steropus*) *madidus*, which measures up to 9 lines long; it is black, has no flying wings, and shows three deep punctures

on the elytra; *Harpalus ruficornis*, common in gardens, which is 6 to 7 lines long, deep black in colour, with the legs and antennæ red; the wing-cases are striated, and are covered with a greyish-yellow pubescence, the antennæ also have a golden pubescence; flying wings are present; and *Calathus cisteloides*, which measures 3 to 6 lines in length; it is black, with antennæ and legs red-brown; there are no functional flying wings.

These four beetles shelter in the daytime in the soil about the plants or among the straw of the beds; they come out to feed at night on the fruits.

Treatment.—Go over the beds, removing the straw, section after section; turn over the exposed soil with a trowel and collect the beetles. Miss Ormerod in one of her reports quotes the treatment adopted on a large scale by the Laxton Brothers of Bedford: "Let into the soil level with the surface a number of cheap pudding-basins, at distances of a few yards apart, keep these baited with pieces of lights and sugar-water. When the weather was dry we often caught half a basinful of a night until the number gradually diminished. The process is laborious, but well worth the trouble, as we have lost no fruit this season."

Gooseberries and Currants.

The Magpie Moth (*Abraxas grossulariata*).—The caterpillars of this moth are very harmful to the leafage of gooseberry and currant. The caterpillar is easy to recognise; it is a looper with 10 legs, has a black head and a yellowish-white body with black spots. The moth flies in late summer and the eggs are laid then; the caterpillars do not complete their growth in the autumn, but hibernate in some shelter-place. Warning is therefore given by the appearance of the caterpillars in autumn, when they don't do much harm, that infestation may be expected in the next spring.

Preventive Measures.—Therefore, when the pests have been noticed in autumn the ground below the plants should be covered with quicklime and dug deeply in winter. In pruning the bushes care should be taken to cut away and destroy any caterpillars that should have found shelter-places on the bushes. Against the feeding caterpillars in spring and summer nothing is better than arsenical washes—viz., arsenate of lead—bought as Swift's arsenate of lead in the paste form—2 lb. to 50 gallons of water; or Paris-green, 1 lb. to 250 gallons of water.

Gooseberry and Currant Sawfly.—The caterpillars of the gooseberry and currant sawfly (*Nematus ribesii*) are sometimes confused with those of the magpie moth, but they are not the least like the moth caterpillars in colour, and they have 20 legs. There are more broods than one of this pest in the year.

Treatment.—The treatment is to bury surface-soil, below bushes that have been infested, in winter along with the cocoons; and against the caterpillars to spray with 1 ounce of hellebore to 3 gallons of water. The hellebore, however, should not be used within six weeks of collecting the fruit.

The Black Currant Gall Mite (*Eriophyes ribis*).—This pest of currants feeds in numbers in the buds and gives rise to what is known as "big bud." Buds that contain large numbers of mites never open but wither away. The mites pass the winter in the buds. Migration of the mites, from dried-up buds that cannot provide food, and from buds that have opened somewhat and so deprived the mites of shelter, takes place from April onwards. The migrating mites seek new buds, and having entered these proceed to lay their eggs. The eggs hatch in due course, and by the end of August "big buds" are found swollen with the new generation. The most favourable time for spray or dusting treatment is while the mites are engaged in moving from the old buds to the new ones. The dusting during this migration period with lime and sulphur—1 part of unslaked lime to 2 parts of flowers of sulphur—is well worthy of trial. The dusting should be repeated three times at intervals of a fortnight. The grower should cultivate from clean stock only.

Aphides.—Currant and gooseberry plants are often badly infested with aphides. If attack has been severe the bushes should be pruned hard in autumn, and the prunings, on which are the eggs, burned. In February the plants should

be sprayed with emulsion-soda wash (see page 457 and Board of Agriculture Leaflet 70), and then careful outlook should be kept for any signs of aphides in later spring, these being sprayed, if seen, with dilute paraffin emulsion before the leaves have time to curl over and so provide shelter for the aphides from the spray.

USEFUL INSECTS.

Certain insects deserve protection from the cultivator, either because as predaceous they prey on other harmful insects, or as parasites they destroy them.

Useful Beetles.—The Tiger beetles, both as adult and as larva, feed upon other insects, the adult chasing them and killing in the open, the larva trapping them in its burrow previous to tearing them to pieces.

Carabidæ or Ground-Beetles.—Although it contains a few harmful species, this family decidedly is useful. The adult beetles are good runners, and prey upon insects and insect larvæ; the Carabus grub is also carnivorous; such grubs are known by their elongated body, 6 legs fitted for running, biting jaws, and two projecting bristle-like processes at their hind end, with a tube between them.

One of the ground beetles *(Zabrus gibbus)* is harmful to corn, while four of them are pests in strawberry-beds—viz., *Harpalus ruficornis*, *Pterostichus vulgaris*, *Pterostichus madidus*, and *Calathus cisteloides*.

Rove Beetles.—The Rove Beetles—family *Staphylinidæ* — are also carnivorous. They can in the adult stage be easily recognised by their very short wing-covers, which do not nearly reach the tip of the abdomen. One of the family is the devil's coach-horse *(Ocypus olens)*, whose habit of erecting its tail-end is well known.

The *Lampyridæ* or Glow-worms, and the *Telephoridæ* or soldiers and sailors —so called from their red and blue colours—are predaceous beetles.

Ladybirds.—Very useful beetles are the ladybirds of the family of *Coccinellidæ*. These small rounded beetles vary in colour,—red with black spots, black with red spots, yellow with black spots. The larvæ are elongated grubs, broadest towards the front end and tapering towards the hind end; they have 6 legs and biting jaws; they come from eggs laid on the leaves of plants, and when full grown they attach themselves by the hind end, gluing themselves by it to leaf or other object, becoming pupæ, which pass on to the adult stage in a fortnight or so in favourable weather. The adult beetles are predaceous, and their active larvæ feed greedily on aphides and scale insects.

Useful Flies.

The *Asilidæ* or Robber-flies are predaceous, the adult chasing on the wing other insects, which are impaled on the rostrum of the robber-fly. Dr Sharp, in mentioning their insatiable appetite, records how a single individual killed eight moths in twenty minutes.

The *Syrphidæ* or Hover-flies.—This is a large family, of which the genus *Syrphus* is made up of black or green flies banded, like wasps, with yellow or orange. The larvæ are legless, their body soft, tapering in front and thicker behind; the mouth is circular, and has two mouth-hooks. These hover-flies lay their eggs amidst a colony of aphides, and the maggots on hatching feed on the aphides, catching them up by their mouth-hooks and sucking them dry.

The family *Tachinidæ* consists of robust, stout, bristly flies. Their larvæ are parasitic on the caterpillars of moths and butterflies. The flies lay their eggs on the caterpillar near the hind end, and the maggots, on hatching, bore into the caterpillar, feeding at first on store of reserve and muscle; later they eat other parts. When full grown they pupate in barrel-shaped puparia inside the spoilt host, or sometimes in the soil.

Useful Hymenoptera.

Apart from the hive or honey bee, and useful for a different reason, we have three families—the *Chalcididæ*, the *Ichneumonidæ*, and the *Braconidæ*. The larvæ of the species of these three families are almost without exception parasitic. Eggs may be parasitised and pupæ, but most commonly larvæ. The range of insect host parasitised is a very wide one, scarcely any insect Order escaping.

The Neuroptera or Nerve-winged Insects.

The members of this Order may none of them be described as harmful. The ant lions are insectivorous, and so also are the larvæ of the lace-wing fly (*Chrysopa*). The female lace-wing fly in her egg-laying touches a leaf with the tip of her abdomen, and elevates the abdomen, giving out at the same time a delicate thread, at the end of which the egg is found. The eggs thus stand out of the reach of other insects. The larva is 6-legged, and has sickle-shaped mandibles; aphides form its chief food.

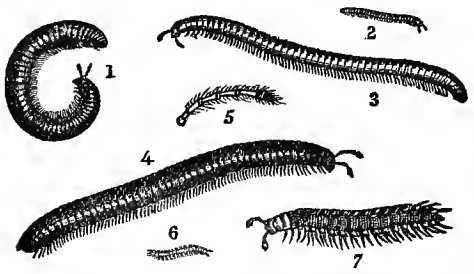


Fig. 661.—False Wireworms.

Snake millepedes: 1, *Julus Londinensis;* 2 and 3, *J. guttatus* natural size and magnified; 4, *J. terrestris;* 5, Horn; 6 and 7, Flattened millepede, *Polydesmus complanatus*, natural size and magnified.

Centipedes and Millepedes.

The *Myriapoda* form a class of jointed-footed animals that have a relation to insects. They have a head with a single pair of antennæ, followed by a number of resembling joints, each carrying legs. There are two sub-classes, the Centipedes and the Millepedes. The centipedes have a flattened body and a single pair of legs to each joint. They are useful, being carnivorous, preying upon slugs and insect larvæ.

The millepedes have a rounded body and two pairs of legs to every seeming joint. They are vegetarian in diet, and are often troublesome in the fields to crop plants with roots and underground stems.

A very common millepede is *Julus guttatus*, which has a thin body, pale-pink in colour, with rows of purple spots; it measures about ½ an inch. *Julus terrestris* is another; it is black, with a pointed tail. Some millepedes are flat—*e.g.*, *Polydesmus complanatus* of the figure.

Millepedes (fig. 661) are often distributed in leaf-mould, and this should therefore be examined before being used. They can also be trapped by placing pieces of hollowed-out mangold or potato beside the food-plants, and slightly covering these with soil. Such traps must be regularly visited. Pieces of mangold and potato soaked in Paris-green poison the millepedes. Another suggested measure is to dig here and there small holes, like the hole on a putting-green, but not so deep; fill with bran and cover with a flower-pot. After some days pour boiling water on to the bran, to kill the millepedes that have been attracted.

Eelworms.

The eelworms belong to the great class of Round Worms and the family *Anguillulidæ*. One of the characteristics of the *Tylenchus* genus is the presence in the gullet of a sharp process, by which plant tissue can be bored and the sap extracted.

Ear-cockle of Wheat. — This is a disease of the ears or flowers in which the grains are replaced by dark-coloured structures. The galls characteristic of the infestation are the result of attack by the minute worm *Tylenchus scandens* (fig. 662). The developing parts of the flower are attacked while in rudimentary condition, and the increased growth which results in the worms being enclosed in the swelling or gall. If such a gall be

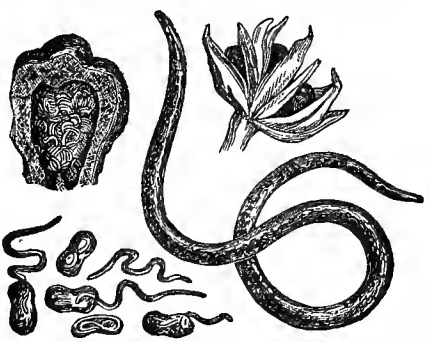


Fig. 662.—Ear Cockles (*Tylenchus scandens*). Wheat cockle-gall; Eelworm.

broken through, eelworms in all stages, egg, young, larger worms, full-grown worms, will be found. A symptom of attack is the puckering of the leaves at their edges.

Treatment.—(1) Do not sow galls along with the grain, as the worms will issue and make their way into the young growing plants, and then make their way to the flower. (2) If the suspected grain be placed in water, the galls rise to the surface and can be removed. (3) Bos recommends steeping infested grain in weak sulphuric acid, 1 pint of sulphuric acid to 33 gallons of water: this kills the worms.

Tulip Root of Oat or Segging (*Tylenchus devastatrix*).—This species of eelworm is the cause of failure in oats, and a contributing cause of clover sickness. In addition, many other plants are attacked—*e.g.*, wheat, onion, lucerne, hop, &c. The roots of infested plants get twisted and swollen (fig. 663), and on their being teased out with a needle, in a drop of water, a more or less spongy appearance is found under the microscope, with decayed matter and the pests. The worms measure up to $^1/_{24}$ inch, and are like miniature eels, with both ends of the body pointed. Eggs and young worms getting into the soil are able to endure desiccation for a long time.

Treatment.—(1) Lengthen out the rotation between crops that are infested —*e.g.*, if the land be clover-sick, clover must not be taken once every four years. (2) As the eelworms leave the plants and get into the soil, plough so deeply that they will be buried and unable to return to the surface. (3) Dressings of various kinds have experimentally proved helpful, one of the most helpful being sulphate of potash.

In experiments at Kew[1] with clover plants it was shown that—(1) Eelworms can infect and kill otherwise healthy clover. (2) That infection can only be effected during the seedling or quite young stage of clover. (3) In the case of infected land, if the eelworms are buried to a depth of 5 inches in the ground, no infection can take place. Hence the advantage of deep ploughing. (4) If a diseased crop is treated with sulphate of potash at the rate of 4 cwt. per acre, the eelworms are destroyed.

Tomato Root-rot (*Heterodera radicicola*).—This eelworm causes knots or swellings on the roots of tomatoes and cucumber. Attack is followed by the stems becoming limp and the plant falling away. The swellings, if dissected, will reveal under the microscope the eelworms. From the eggs come tiny worms, shaped like eels. Later there is a swollen or cyst stage from which the male emerges, still with the shape of an eel, but the female, swollen with eggs, is pear-shaped.

Fig. 663.—Tulip-rooted Oat plant infested by Eelworm (*Tylenchus devastatrix*).

If the soil be saturated with 1 part of carbolic acid in 20 parts of water, the eelworms are killed; such soil cannot be used for a month afterwards. The mixing of naphthalene with the soil as a fumigant has some success.

Other plants are attacked by this same eelworm—*e.g.*, beet, carrot, clover, black medick,—and this increases the risk of spread.

Literature.

The literature of Economic Entomology is an ever-increasing one. Never before has there been so much activity. The Board of Agriculture extends a general invitation to farmers to avail themselves of its aid as regards insects of the farm. The Royal Agricultural Society of England and the Highland and Agricultural Society of Scotland offer facilities to their members, while agricultural colleges and societies up and down the country are doing useful entomological work. The Reports published by these various societies, and the series of leaflets distributed free by the Board of Agriculture, form a yearly increasing part of the literature. The Annual Reports of Mr Fred. V. Theobald, Vice-Principal of Wye, of Mr Cecil Warburtou of Cambridge, of Mr W. E. Collinge, late of Birmingham University, of Professor Carpenter of Dublin, and of Dr Stewart MacDougall, University of Edinburgh, should be consulted, as every year they contain something new. The old Annual Reports of the late Miss Ormerod and of Mr Charles

[1] *Journal of Board of Agriculture*, July 1907.

Whitehead, accessible only in libraries, will be found very useful. The two volumes on Insects by Dr Sharp, in the Cambridge Natural History Series, form a magnificent contribution to the literature of Entomology on its scientific side. The late Miss Ormerod's *Manual of Injurious Insects*, now out of print, is being rewritten, and the new edition will not be long delayed.

In the United States there is in the Annual Reports of the various States a mine of useful information on crop insects, and the literature of Canadian Entomology cannot be neglected. Finally, the farmer who may chance to settle abroad will find in the various British Colonies not named an Official Consulting Entomologist whose reports give the salient features in the Economic Entomology of the year.

SNAILS AND SLUGS.

The *Helicidæ* (Snails) and the *Limacidæ* (Slugs) are two families of the class *Gasteropoda*, a class belonging to the Phylum *Mollusca*. This Phylum of invertebrate animals numbers in it mussels, cockle, oyster, snail, slug, whelks, limpet, and the cuttlefishes. As is only too well known, snails and slugs do a good deal of harm to many garden and field crops.

Snails and slugs have a fairly well-developed head region, and a muscular process known as the foot by which the animal moves. They are further characterised by the possession of a rasping ribbon known as the radula; this radula has on it rows of horny teeth, and under the microscope resembles a file; this file is pulled backwards and forwards by the working of muscles, and by means of it particles of food are scraped off. On the roof of the mouth, and seen on separating the lips of the snail, is a horny, crescent-shaped jaw, which acts with the rasper, and so leaves and leaf-stalks are cut. Traces of rasper and jaw can be found on leaves, and if there be silence, the working of the mouth-parts of a grazing snail can be heard. Eyes are present, but the most delicate and accurate sense is the sense of smell.

Both snails and slugs are hermaphrodite. The eggs, which have a parchment-like shell, are laid on or in the soil, or under heaps of leaves, or under stones. There is no metamorphosis in the life-history, a tiny snail, resembling the adult externally, hatching from the egg.

Air is breathed directly, being taken in by a respiratory pore to a pulmonary chamber or lung.

In habit, snails and slugs are crepuscular or nocturnal, but in damp weather or after heavy rain they may be found out and about, feeding, in the daytime. In dry sunshiny weather shelter is sought in the soil or under stones.

SNAILS (*Helicidæ*).

These have a spiral shell into which the whole animal can be withdrawn. In habit they are almost exclusively vegetable feeders.

The Garden Snail (Helix aspersa, Müll.)

This snail measures up to $1\,^2/_5$ inch; the spiral shell has $4\frac{1}{2}$ turns, is brown in colour, and has spiral bands or lines crossed by transverse patches. White globe-shaped eggs are laid in batches in the soil; these hatch in about a month. The snails remain dormant in a place of shelter during the winter. The length of life may be five years. The species is harmful in gardens to vegetables and to the leaves and blossoms of fruit-trees.

The Wood Snail (Helix nemoralis, Müll.)

This snail measures an inch in length; the shell has $5\frac{1}{2}$ turns; the colour of the shell varies much; the lips of this snail are brown or black.

Helix hortensis, Müll.

Measures an inch; has spiral bands, but no transverse patches; the lips are white.

The Strawberry Snail (Helix or Hygromia rufescens, Penn.)

Measures up to $\frac{1}{2}$ an inch long; 6 to 7 turns to the shell; the shell is compressed above, is reddish-brown in colour,

and often has a white band on the last turn; the snail itself has brown stripes on neck and tentacles, and the foot is narrow and pale. This snail is sometimes very troublesome in strawberry beds, and vegetables and garden flowers are also destroyed.

The Hairy Snail (Helix or Hygromia hispida, Linn.)

Measures ⅓ of an inch; six to seven turns to the shell; colour grey-brown. Short hairs are present, white on the epidermis and red on the first part of the shell to be formed. Found in gardens and in osier beds.

The Small Banded Snail (Helix or Helicella virgata, Da Costa).

Measures ½ an inch; colour white, with purple-brown stripes. Its typical habitat is dry downs with short turf, but besides its destruction of grass there are records of harm to wheat and root crops.

The Allied Banded Snail (Helix or Helicella caperata, Mont.)

Measures ⅓ of an inch or less; the shell has keels or ribs on the turns, and has coloured stripes. Found on dry downs, gardens near the sea, in cornfields and woods.

SLUGS (*Limacidæ*).

Except the genus *Testacella*, none have an external shell; most, however, have a rudimentary plate-like shell hidden below the skin of the back, or at least a few limy granules; the region in the slugs which is over the rudimentary shell is known as the shield. Some have a large slime pore at the end of the foot.

The Large Black Slug (Arion ater, Linn.)

The species of the genus *Arion* have the respiratory pore half-way along the shield; the shield is shagreened, the skin is wrinkled, and there is a slime gland at the hind end of the body.

In *Arion ater* the prevailing colour is black, but it may be brown, yellowish-green, &c.; the edges of the foot yellow-white; the shell is made up of loose limy granules, irregular in size. A large number of eggs is laid; one individual laid 577 from 13th October to 30th November; the eggs hatch in forty days or more, according to the temperature. The slug is full grown in a year and a half, and measures 4 inches in length. The large black slug is found in gardens, woods, and along hedge-sides. It is omnivorous in diet—vegetarian and carnivorous—and can be harmful both in field and garden.

The Garden Slug or *Small Arion* (Arion hortensis, Fer.)

The colour is very variable; the shield shows three stripes, and there are also grey stripes on the back and sides; the oval shell is granular. This slug is found both in field and garden, and may do much damage.

The Black Striped or Mottled Slug (Limax maximus, Linn.)

In the genus *Limax* the respiratory opening is at the hind end of the shield or in the posterior half; the shield is also concentrically wrinkled.

Limax maximus measures up to 6 inches and over in length; it is grey in colour, with black spots, but the colour is variable; the tentacles are purple; the body is tubercled; the foot is edged with white. In diet it is vegetarian and carnivorous.

The Grey Field Slug (Limax or Agrolimax agrestis, Linn.)

Measures when full grown 1½ inch; the colour is mottled ash-grey, but, as with other slugs, it varies much; the body is elongated and spindle-shaped. The shell is small and oval. A large number of eggs is laid from May onwards, these being laid in small batches up to fifteen in each. This is an exceedingly destructive species, probably the worst of all, levying toll on many plants, peas, beans, clover, cabbage, young turnips, wheat, strawberries, pansies, carnations, and many other garden plants.

The Household or Cellar Slug (Limax flavus, Linn.)

Measures up to 4 inches in length; colour variable, but typically is yellowish with brown-black spots; the head and tentacles are grey or blue-grey; the under surface of the foot white, and the

edges of the foot yellow-white. It gives out abundant slime. This slug is found in the open, but it is more commonly found indoors in cellars, sculleries, pantries, &c., where it feeds on bread, meal, flour, &c.

The Root- or Bulb-eating Slug (Milax Sowerbii, Fer.)

In the genus *Milax* the respiratory opening is on the right side in the posterior half of the shield; the shield is shagreened; there is also a well-marked keel along the back of the body.

Milax Sowerbii is yellow in colour, but may be grey or brown, or even on occasion black. It is a destructive garden pest to such strange organs as stem and root tubers and bulbs, and to many garden plants whose leaves are pulled into the ground; it is also carnivorous, taking caterpillars and small slugs.

PREVENTIVE AND REMEDIAL MEASURES.

1. Snails and slugs have numerous animal enemies—*e.g.*, rats, voles, hedgehogs, and shrew-mice.

There are several bird enemies of these pests. The thrush is well known for its destruction of snails, while blackbirds and starlings and ducks greedily take slugs.

Among insect enemies are ground beetles and beetles of the family *Staphylinidæ*.

2. *Hand-picking* should be practised in gardens. In some parts of the Continent the people have a most effective way of keeping *Helix pomatia* in check —viz., by collecting and eating it. In some parts of the west of England the garden snail is said to be collected for use in chest complaints, and the same slug has been reported elsewhere as of use in preparing a substitute for cream, particularly in rearing calves.

3. *Trapping* —By means of lettuce or cabbage leaves (in the case of the strawberry snail) or by little heaps of bran, or by means of boards laid along garden beds; these boards are sometimes greased or larded on the under side, and here the pests collect.

4. *Irritant dressings*—In the application of these, two points must be kept in mind: firstly, that the time for a dressing will not be in the middle of a hot day, but at such times as the pests may be out—*e.g.*, in early morning or late in the day, or after rainy weather; secondly, it should be remembered that a single dressing is not enough, for these molluscs have the power of secreting much slime, and in this way they may receive protection, or the dressing may be moulted off: after a third outpouring of slime, however, the animal has exhausted for the time its power of slime-secretion, and then the dressing accomplishes its result. Irritant dressings are soot and lime, or soot and salt, or salt and lime. Theobald records success with a mixture of fine lime with 4 per cent of caustic soda, 12 bushels to the acre, or with salt with 4 per cent of caustic soda, 4 to 5 bushels to the acre. These were broadcasted on the field early in the morning or late at night. Plants, too, round which the material was spread, received protection.

5. On land that has been very badly infested with slugs, gas-lime should be spread late in autumn, and after being allowed to lie for six weeks should be ploughed or trenched in; this is destructive to the slugs and their young.

Slugs that devour Worms and Insect larvæ.

Slugs of the genus *Testacella* are, from the grower's standpoint, useful, and should be protected. They are predaceous, living in the soil and preying on worms, insect larvæ, smaller snails, and slugs—*e.g.*, *Limax agrestis*. The teeth on the radula are long. Slugs of the genus *Testacella* can be recognised by their having a rudimentary external shell at the tail end of the foot. There are three species of *Testacella* found in Britain—viz., *T. haliotidea*, Drap., *T. scutulum*, Sby., and *T. mangei*, Fer. The first is the longest, measuring from 3½ to 4 inches. The eggs are laid singly in the soil.

LITERATURE.

British Conchology, by T. Gwynn Jeffreys, F.R.S.

Injurious Mollusca, by Fred. V. Theobald, M.A., in *Zoologist*, June 1895.

Injurious and Beneficial Slugs and Snails, by Fred. V. Theobald, M.A., in the *Journal of the Board of Agriculture*, January and February 1905.

Slugs, by Scharf, in *Scientific Transactions of the Royal Dublin Society*, iv. (2), p. 520.

DAIRY WORK.

Along with other matters relating to the live stock of the farm, the breeding, feeding, housing, and general management of cows and their live produce are fully discussed and described at convenient points in vol. iii. of this work. The manipulation and utilisation of milk and its products are dealt with here.

The cow—the best friend to man of the entire animal creation—gives a bountiful yield of a delicious fluid, which, although universally familiar to the eye and welcome to the palate, is neither so well understood nor so skilfully manipulated and utilised as might be reasonably expected in the enlightenment of the present day. What, then, is this fluid? and what shall we do with it?

The notes in the following pages, intended to elucidate these two comprehensive questions, are not addressed in any exclusive sense to those who are usually described as "dairy farmers"—those who make dairying their sole object, or the one great, all-absorbing feature in their farming. The information is designed for all who have milk to manipulate, in large or in small quantities. Whether it happen to be the milk of the crofter's one cow, the stinted produce of the breeding herd, or the fuller flow of the heavy milkers on the large dairy farm, the object all through should be the same—to turn the milk to the best possible account. Whether this will be as food for the residents on the farm, for calf rearing, for sale as whole-milk, skim-milk, cream, butter, or cheese, will depend upon circumstances too numerous, involved, and variable to be discussed here with advantage. Whatever the destiny of the milk may be, it is important, in order to ensure the best possible results in its utilisation, that the operator should be acquainted with the characteristics, the inherent properties, the weak points and the strong, of the commodity which he or she is handling. It is thus desirable that all who keep cows, whether few or many, should make themselves familiar, not only with the characteristics and properties of milk, but also with the best methods of preparing it for the various purposes for which it may be used.

THE DAIRY.

In the section on Farm Buildings information is given as to the erection of buildings for dairy farms (vol. i. p. 147). It is not necessary, therefore, to say much here regarding the construction of dairies. In capacity and equipment the special apartments designed as the dairy will be regulated in accordance with the extent and nature of the dairying operations carried on upon the farm.

Upon mixed husbandry farms, where dairying is quite a subsidiary interest, or where, indeed, only as many cows are kept as will supply the wants of the farm itself, the dairy or "milk-house" is often merely a small compartment easy of access from the dwelling-house. Formerly on such farms the "milk-house" was usually in direct communication with the kitchen, but now the sanitary regulations of almost all counties prohibit direct access from any part of the dwelling-house to an apartment in which milk is kept.

Upon holdings where dairying bulks largely, the manipulation of the milk and its products may require a distinct set of apartments of considerable dimensions.

Be the extent of the dairy what it may, there are some important conditions which should be common to all. Leaving individual farmers to secure the dairy capacity required for their respective holdings, and also allowing them the fullest freedom in what may be called the embellishment of their dairy buildings, we would press for general adoption only such conditions and arrangements as are known to be essential for the hygienic handling and successful manipulation of milk, butter, and cheese.

Situation of the Dairy.—In the first place, the milk compartment or

dairy should be so situated as to be free from strong or unpleasant odours. Unless it is kept perfectly sweet, airy, and wholesome, successful dairying is out of the question. Hence the importance of avoiding direct communication with the dwelling-house. Where the milk-room has direct access from the dwelling-house, odours from the kitchen, scullery, and pantry are liable to find their way into this compartment, and play havoc with the milk, cream, and butter. If the dairying interests of the farm are too small to justify the erection of a separate dairy, make a point of having the milk compartment as far removed from the kitchen, scullery, and pantry as possible. Let it be in a cool, airy position, on the north side of the house if possible. Keep nothing in the milk compartment except milk or butter — above all, nothing that gives off a strong or unwholesome smell.

A Medley in the Milk-room.—An arrangement by no means uncommon upon farms where little attention is given to dairying, is to have the milk-house and pantry combined in one compartment. Here, in close proximity, perhaps on one shelf, are milk, butter, cheese, old and new; cold meat from the table, dripping, fish, fresh and cured, and such odorous, savoury and unsavoury articles. A worse arrangement for the milk and butter could hardly be conceived. Those who desire to have first-class, good-keeping dairy produce, must protect it from all such contaminations.

Separate Dairy.—A convenient position for the separate dairy is right back from the kitchen on the north side of the house. It is a good plan to have the kitchen and dairy connected by a covered passage, leading through a yard perhaps from 5 to 10 yards wide. It is desirable, of course, that the dairy shall be within easy access from the cow-house, yet not so close as to endanger the tainting of the milk with smells from the byre, dungstead, or piggery.

Compartments in the Dairy. — In all cases it is desirable to have at least two compartments in the dairy, — one where the milk may be kept as cool as possible, and where the cream may be prepared for churning and the butter stored previous to despatch or use; the other being reserved as a washing-up room or scullery. Particular attention must be given to ventilation, so that the steam from the boiler and wash-tubs may be speedily carried off. There should not be a drain within the building, but an open channel provided to carry away all waste. This open channel should have a run towards one end into a drain-trap outside the building. Where cheese is made one room is also necessary for the making of cheese and another for the ripening of it, as the temperature and moisture in the air of the dairy may be unsuitable for the ripening of cheese.

Verandah.—It is a good plan to have a covered way or verandah along the south front of the dairy. This provides a shade from the noonday sun, and permits the dairy utensils being dried and aerated in rainy weather.

Finishings of the Dairy.—There is no need for elaborate or costly buildings for dairy work. They should be fairly roomy, not less than 10 feet in height, well ventilated and thoroughly dry, with a subdued rather than bright light. The ceiling should be lathed and plastered, and the flooring formed of some material which will be hard, have no crevices, be proof against damp, and easily cleaned. Encaustic or enamelled tiles and polished pavement are often used, but there is nothing better than well-formed concrete with a smooth surface. The concrete floor is rounded at the edges and corners, and declining towards the door or other exit, so that with a hose-pipe and a good supply of water it can, with little trouble, be thoroughly flushed.

Dampness to be avoided.—Dampness is very injurious in the dairy. If the situation is of a damp nature, special precautions must be taken in constructing the dairy to ensure that its floor and walls shall be proof against damp.

Milk Shelves.—Since the introduction of the cream-separator we have seen many milk shelves taken out of the dairy and the setting-pans discarded. Yet there are many farms where the milk is still stored on flat pans where it is intended for sale, or is "set" for the hand-skimmer. Such shelves should be

of some non-absorbent material such as slate or flagstone. These may, with advantage, be erected with a space of about 3 inches clear from the wall, so that cleansing may be thorough, and no crevices for the accumulation of objectionable matter exist when this plan is adopted.

Temperature of the Dairy.—It is a matter of great importance to have the dairy kept cool, sweet, and fresh. To secure, as far as possible, a cool, even temperature, the dairy is sometimes sunk partly into the ground on a hillside, great care being given to the drainage; while walls and roofs are made double, with an air-space between. In summer the windows and doors are well shaded from the sun, and it is considered that a subdued is preferable to a bright light in the dairy. Specky or streaky butter is sometimes attributed to exposure to strong rays of light.

Precise limits need hardly be laid down as to the temperature of the dairy. The object to be aimed at is to have the atmospheric temperature of the milk-room lower than the temperature of the milk itself.

Professor Sheldon remarks that "milk that has been cooled by water or ice should not be exposed to an atmosphere 10° or 20° warmer, for it then becomes a facile condenser and absorbent. While the air is seldom pure enough not to injure milk that is 10° colder, it is seldom so impure as to vitiate milk that is 10° warmer." [1]

There is thus good reason for keeping the atmosphere of the milk-room cool, fresh, pure, and dry.

Importance of Temperature.—At every step in dairy work, no matter what branch of dairying may be pursued, the guidance of the thermometer must be constantly resorted to. Temperature is a controlling influence in all the operations of cream-raising, milk-ripening, butter-making, and cheese-making; and without due attention to this influence success cannot be reckoned upon. Guess-work is quite unreliable, both as to the temperature of the room and of the commodities under manipulation. But there is a simple and efficient guide at hand—the common thermometer—which may be had specially adapted for dairy work at from 1s. to 3s. each.

Thermometers.—Glass or porcelain thermometers are required for inserting in and marking the temperature of milk, curd, &c. There should also be a wall-thermometer hanging in every compartment of the dairy, so that the temperature in each may be seen at a glance. The use of a thermometer provided with a case of wood, to prevent breakage under rough handling, is objectionable for insertion amongst dairy produce, for it is sometimes the cause of much trouble in butter-making. It is liable to be imperfectly cleansed after use, and day by day the cream may thus be inoculated with undesirable organisms from this thermometer.

Dairy Utensils.

In regard to the kind of dairy appliances to use, it would be imprudent to dogmatise. In recent years vast ingenuity and enterprise have been employed in the bringing out of "new and improved" dairy appliances. We heartily acknowledge the benefits which have thus been conferred upon the dairy interest, for it has been established beyond question that many of these modern contrivances for use in the dairy are possessed of merits of the highest order.

Still it is not necessary that in order to ensure first-class dairy produce the dairy farmer should discard all his old appliances and adopt new ones. He will do so only as far as his experience, observation, and means seem to dictate and justify. This is pre-eminently one of those points as to which the dairy farmer may, with ample justice to the produce of his dairy, give considerable scope to his purse and his fancy.

Important points to look for in all dairy appliances are simplicity and economy in working, facility in cleaning, and durability. Cheapness is, of course, also to be kept in view. The greatest consideration of all is efficiency.

Power for the Dairy.

There are many cases where all the separating of milk, churning of cream, and even pumping of water are now done by hand, while at little expense

[1] *The Farm and Dairy*, 62.

these could be driven by the existing power on the farm. Where there is a water-wheel or turbine for driving the farm machinery, the power might be conveyed to the dairy at very slight expense, and for dairy work this power might be had early in the morning without the necessary delay where steam has to be raised. Where a separate installation is to be made for the dairy, a small vertical cross-tube boiler and a steam-engine serve the purpose well. So much cleansing of utensils has to be done, that the greatest benefit is derived from the use of live steam. The water may be boiled by introducing a jet of live steam into the cleansing-tank. For the cream-separator an electric motor is an excellent source of power, as both are high-speed machines.

MILK.

Milk possesses characteristics which should be carefully studied by those who have to handle it and manufacture its products.

Composition.

The composition of cow's milk varies greatly. The following may be taken as fairly representing (1) the analysis of an average sample of milk; and (2) the extremes in milk-analyses:—

	Average Analyses.	Extremes of Ingredients.
Water .	87.40	81.00 to 91.00
Casein . .	3.30	3.00 " 4.10
Butter-fat . .	3.40	1.85 " 9.50
Milk-sugar . .	4.55	3.00 " 5.00
Albumen . .	0.60	0.30 " 1.20
Ash . . .	0.75	0.70 " 0.80

The range of solid matter in milk is as great as from 9 to over 19 per cent. A good sample should contain over 12 per cent. Different breeds vary greatly in the standard percentage of solids in their milk. Dutch cows rank lowest, Jersey cows highest, shorthorn cows being about the average. Even with the same cows there will be marked variations under good and bad treatment, and in accordance with the period of lactation.

Butter-fat.—It will be observed from the figures given above that the greatest variation occurs in the butter-fat. In many samples of milk from Jersey cows, analysed at the London Dairy Show by Mr F. J. Lloyd, the percentage of total solids ranged from 13 to over 19 per cent, and this variation arose almost entirely in the butter-fat. The percentage of butter-fat ranged from about 4.10 to about 9.50 per cent, while total "solids other than fat" showed only very slight variation, at most considerably under 1 per cent. With the milk of shorthorn cows analysed on the same occasion, exactly similar results were obtained—that is, in regard to the variability in the percentage of butter-fat, and the comparative fixity in that of the other solids. The total solids in the shorthorn milk ranged from 11 to 15 per cent, while the solids *other than butter-fat* did not vary more than about one-half per cent.

Yield of Butter.—The yield of butter varies considerably, not only as between breeds but also amongst cows of the same breed. From about 1⅓ to 1⅔ lb. of butter per day are general yields. In regard to butter ratio—that is, the number of pounds of milk to one pound of butter—the Jersey breed takes the highest place with from about 18 to 20, Guernseys coming next with 19 to 21, and Kerries and Dexters following with about 21 to 22. The following table gives the highest and lowest yields of butter from over 600 cows of the breeds mentioned, at the London Dairy Show, during the twelve years from 1895 to 1907:—

Breed.	Average No. of days in Milk.	Average weight of Butter.	Average Butter Ratio.
		lb. oz.	
Shorthorns . .	44	2 0½	26.69
" . .	58	1 6¾	32.87
Jerseys . .	117	1 13½	19.62
" . .	141	1 9½	17.80
Guernseys . .	82	1 12½	18.90
" . .	138	1 3¼	27.00
Red Polls . .	80	1 8⅜	25.50
" . .	76	15	39.15
Ayrshires . .	52	1 13¼	26.35
" . .	77	1 2½	28.07
Kerries and Dexters	33	1 13	22.4
"	72	14¾	21.31

Composition of Milk from Different Breeds.—The following table gives the average daily yield of milk in pounds, with the fat and total solids in the milk, calculated out for each breed from the results of trials with 482 cows at the London Dairy Shows in the years stated:—

Breed.	Years.	No. of Cows.	Lb. of Milk.	Fat. %	Total Solids. %
Shorthorns	1900-1904	123	48.8	3.72	12.61
"	1907	17	47.9	3.56	12.51
Lincoln Red Shorthorns	1907	7	51.8	3.41	12.36
Jerseys	1900-1904	111	31.3	5.20	14.40
"	1907	12	34.9	5.10	14.27
Guernseys	1900-1904	36	31.5	4.58	13.65
"	1907	5	35.7	4.59	13.93
Red Polls	1900-1904	33	40.5	3.70	12.70
"	1907	8	41.5	3.62	12.49
Ayrshires	1906	3	42.5	3.56	12.58
"	1907	3	33.5	3.22	12.07
South Devons	1906	5	48.3	3.72	12.93
Kerries	1900-1904	43	30.9	4.12	13.26
"	1907	5	40.3	4.30	13.28
Dexters	1907	8	31.0	3.66	12.72
Crosses	1900-1904	50	45.1	3.92	12.86
"	1906	13	46.4	3.54	12.68

A comparison of these figures corroborates many points with which we are already familiar. Thus Shorthorn milk is not very rich in total solids or fat; Jerseys and Guernseys are very high in fat and total solids; Kerry cows above the average; and the others medium. If the solids other than fat are worked out, it will be found that they vary only within a half per cent, not only within the limits of the breed, but between the averages of all—that is, they exist in the proportion of from 8.85 to 9.34 per cent, as against a variation in the total solids of from 12.07 to 14.40 per cent.

It is thus established beyond question that by far the most variable ingredient in milk is fat. It is the commodity which is most within the control of the farmer, and which will be chiefly influenced by the breeding of the cow. The fat, of course, is the ingredient from which the butter is derived.

Testing Percentage of Cream.—The ordinary *test-tube*—a glass tube with graduated lines at the top to mark the percentage of cream as it rises—is useful, but not quite reliable. The milk is put into this tube as it is drawn from the cow, and when the cream has risen, it shows on the graduated scale the percentage of the bulk of the cream. But the cream of different cows varies so much in the size of the butter-fat globules, and therefore in specific gravity, that this test will not always show the entire and exact comparative quantities of butter-fat in samples of different milk.

The *Lactocribe* is a useful invention for ascertaining the exact amount of butter-fat in milk. It is worked similarly to the De Laval separator, and tests the milk by centrifugal force—making as many as twelve tests at one time. It is specially useful in dairy factories or creameries, where cream is purchased from the farmers.

The "Gerber" butter-fat tester is largely used in private herds. It does its work well, and by it each cow's milk can be tested at a cost of about ¼d. per test.

Fat-globules.—The butter-fat may be seen by the microscope to be in suspension in the milk in tiny globules. These globules vary in diameter in the milk of different breeds and different cows from $\frac{1}{2000}$ to $\frac{1}{20000}$ of an inch, and it has been estimated that there are over forty thousand millions of these fat-globules in a pint of milk containing 4 per cent of fat.

Casein.—This useful ingredient of milk, so important in the manufacture of cheese, is described as existing in the milk in the form of an extremely attenuated jelly, owing to lavish absorption of water. There has been much discussion as to how far the percentage of casein can be influenced by the food given to the cow. Mr F. J. Lloyd says he is sure every chemist who has analysed milk will confirm his statement, that "we cannot by feeding perceptibly increase the casein contents of milk"; and he adds, that therefore the object in cheese-making should be to feed so as to increase the flow of milk and keep down the fat—that is, unless a rich cheese is desired,

when more albuminoids are given in the food to increase the fat. Some practical dairy farmers contend that, by changes in feeding, they have been able to alter the casein contents of the milk, but the general experience is in accordance with the views expressed by Mr Lloyd.

Milk-sugar.—This is usually present in a larger quantity than any of the other solid ingredients. It is the most active agent in the decay of milk, as by the action of germs, *Bacterium lactis*, it is transformed into lactic acid, producing sour coagulated milk.

Albumen. — This nitrogenous substance is very similar to casein. Yet the two are so different that, while the rennet precipitates casein in the form of curd, the albumen passes off with the whey. It is this albumen and the sugar of milk that give to whey the feeding value it has been shown to possess (see section on Food and Feeding, vol. iii.) This albumen coagulates on boiling the whey *after* the removal of the casein. It forms the skin which appears on boiled milk.

Weight and Specific Gravity.—A gallon of whole-milk weighs as near as might be from 10.25 to 10.35 lb. For simple calculation, it is a common practice to reckon 10. lb of milk to the gallon. The specific gravity of whole-milk would vary from about 1.025 to 1.032, as compared with 1.000 for water as the standard. The higher the percentage of fat the lower the specific gravity of the whole-milk. The specific gravity of cream itself is about .90.

Milk Statistics.—Taking the stock of cows in this country as a whole, the average yield of milk would probably be somewhere between 500 and 550 gallons of milk each per annum. Good average dairy cows of the heavier milking breeds —shorthorn, cross-bred, Ayrshire, Dutch, and red polled—should give from 700 to 900, some of them even more than 1000 gallons each in the twelve months. Fuller information as to the milk yield of cows of the different breeds will be found in the section on Breeds of Cattle in vol. iii. The produce of butter from a given quantity of milk varies greatly. The choicest butter cows, such as Channel Island cows, often give 1 lb. of butter from rather less than 2 gallons of milk, and average dairy cows in a butter dairy should give a pound of butter from 25 to 30 lb. of milk. Cheese-makers expect to get about 1 lb. of hard cheese, such as Cheddar, from each gallon of milk, and a little less in Stiltons.

Milk Records.—It is very desirable that the product per day of every cow in milk should be tested by weight, and for butter-fat at least one evening and one morning every two or three weeks. Many, indeed, insist upon this being done every day. Useful information will thus be obtained as to the return each individual cow is giving for the food she consumes. In the absence of precise facts as to the yield, unprofitable cows may be occasionally kept on longer than would otherwise be the case. The great value to the farmer of records of the milk yield of cows has been well demonstrated by the movement set on foot by the Highland and Agricultural Society of Scotland in the year 1904, when it introduced a scheme for the systematic recording of the produce of milk given by cows in herds of Ayrshire cattle. Farmers are being greatly aided by these records in raising the milk production of their herds. Not only do the records guide farmers in buying and selling cows, but also in the selection of animals for breeding purposes.

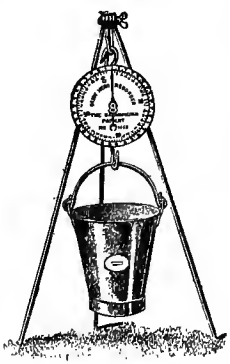


Fig. 664.—*Sandringham dairy herd recorder.*

Appliances for Weighing Milk. — A convenient appliance for weighing and measuring milk is represented in fig. 664.[1] The dial shows the weight of the milk in pounds and ounces, and the measure or quantity in gallons and pints.

Along with this useful instrument the Gerber butter-fat tester may be used, and each cow's milk tested at a cost of about ¼d. per test.

[1] *For a number of the illustrations presented in this section we are indebted to the Dairy Supply Co., Ltd.*

PURIFYING AND PRESERVING MILK.

It has been the custom for ages to treat milk for the purpose of keeping it pure, fresh, and sweet as long as possible. In olden times the chief means used for this purpose was the mixing with the milk such preservatives as boracic-acid or borax, formaline, and saltpetre. In small quantities these preservatives may not be very harmful to health, but strong objections are now urged to the use of any such agents in milk. Fortunately the more enlightened methods of Refrigeration, Pasteurisation, and Sterilisation are at our service nowadays.

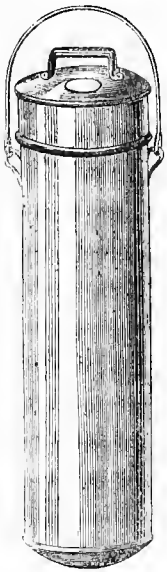


Fig. 665.—*Pasteuriser tin can.*

There are several processes by which milk may be to some extent purified and preserved sweet and wholesome for a time. As soon as milk is exposed to the atmosphere it is liable to absorb not only bad odours, but also living organisms (minute vegetable growths), which are continually floating about, and which accelerate the souring and decaying of milk. The action of these organisms is very much impaired by cooling the milk to about 50° or 55° Fahr., and this is frequently done as soon as the milk is taken to the dairy. It is also believed that by heating the milk to at least 170° the most of these living germs are killed. In hot weather, therefore, when it is difficult, mainly on account of the activity of these organisms, to keep the milk sweet for any length of time, it is the custom in some dairies to heat the milk up to from 150° to 170° Fahr., and then rapidly cool it to below 50°. The boiled taste in milk begins to be developed about 156° Fahr., and care should be exercised in heating milk not to go much beyond this temperature when it is intended to be used in the fresh state as either food or drink.

Pasteurisation of Milk.

The method adopted in heating milk depends upon the quantity to be dealt with and the form of heat available. If only a small quantity is to be heated, a pasteurising can (as in fig. 665) may be used. This is made very deep so as to afford as much heating surface as possible. It is fitted with a plunger, which works through an opening in the lid. The tin can is immersed in hot water, and by means of the plunger the milk is agitated and kept from singeing while heating. Such an appliance is very well suited for dealing with small quantities of milk or cream.

Where large quantities of milk have to be dealt with, other methods have to be adopted. The practice of raising the temperature of milk by means of a jet of live steam introduced into it is to be condemned. The water used for raising steam may contain many impurities, which decompose and give off obnoxious gases at a high temperature. These gases may be transmitted to the milk with disastrous results. There is also a considerable amount of water added to the milk which is so heated.

The Turbine-driven Pasteuriser.—This machine (fig. 666) consists of a double-jacketed cylinder. A jet of steam drives a turbine wheel and exhausts into the jacket, which surrounds the cylinder through which the milk passes. Here it is condensed, and passes out through a siphon situated beneath the machine. On the steam inlet pipe a pressure gauge is fitted, so that the speed of the stirrer driven by the turbine wheel may be regulated. The receiving-funnel communicates with the bottom of the inner cylinder, and the milk passing through this opening is

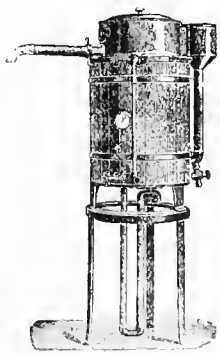


Fig. 666.—*Turbine-driven pasteuriser.*

caught by the wings of the stirrer and revolved round the hot wall. In flowing out at the top of the machine the milk passes a thermometer, which indicates the temperature. If, however, the inflow of milk is kept constant, and the pressure of steam constant, then little trouble will be experienced in variation of temperature. This machine is particularly well suited for dairies and creameries where there is no steam-engine or other similar source of power.

Belt-driven Pasteurisers. — This machine differs from the turbine pasteuriser in the manner in which the stirrer is driven. A stirrer is necessary to prevent the milk-sugar burning and imparting a cooked flavour to the milk, and also to prevent the casein from being deposited on the walls of the machine. Where there has been a deposit of casein the efficiency of the pasteuriser is greatly impaired, and much steam may pass out at the exhaust siphon before it has an opportunity to condense. This deposit must be removed with a brush; and a solution of washing-soda left overnight in the machine will greatly aid in its removal. This pattern of pasteuriser may be fitted with a tight-fitting lid and the stirrer driven at such a speed as will elevate the milk 6 to 10 feet above the machine. In creameries this may be a great advantage, for in many cases the milk has to be raised to a high level in order to flow by gravitation over the milk coolers. Where there is exhaust steam from an engine this may be used for heating purposes in the pasteuriser, care being taken to have a safety-valve fitted to the jacket to prevent injury to the thin copper cylinder into which the milk passes.

Motor-driven Pasteuriser.—A small engine, with oscillating cylinder fitted on to the frame of the pasteuriser, may be employed in place of the turbine wheel. The exhaust steam from this cylinder enters the heating jacket, which may also be fitted with a steam inlet for live steam to ensure sufficient heating power independent of the speed at which the motor may run.

Sterilisation of Milk.

Many people consider pasteurisation and sterilisation to be synonymous terms. This, however, is not the case. The object of pasteurisation is to destroy the bacteria which are present in the milk, and in this process a temperature between 160° Fahr. and 175° Fahr. serves the purpose. Milk so treated in sultry trying weather will keep sweet for 24 hours longer than milk which has not been raised to that temperature, but it must not be assumed that it has been rendered sterile or that germ life has been entirely destroyed. The object of sterilisation, on the other hand, is not only to render the milk free from bacteria, but also free from spores. The spore or resting stage in the life of the bacillus is much more resistant than the active bacillus, and must be subjected to a temperature about 230° Fahr. for 20 minutes. This temperature cannot be attained under atmospheric pressure, and so the design of a steriliser differs from a pasteuriser in being made to withstand a pressure of 40 lb. to 50 lb. per square inch.

Fig. 667.—*Bottle for sterilised milk.*

Sterilised Milk in Bottles. — It is usual in practice to sell all sterilised milk in bottles (such as that in fig. 667). These bottles are filled with raw milk and then set into the machine. When the bottle is taken from the machine, the milk, under atmospheric pressure, is boiling vigorously, and consequently a stream of vapour passes from the mouth of the bottle, which prevents contamination from the atmosphere gaining access until the bottles are sealed up. In the more modern sterilisers the bottles are corked while still under steam-pressure.

A steriliser which is known as a "Sterlicon," and is designed to deal with large quantities of milk, is fitted with an automatic arrangement for closing the bottles as they pass out of the machine. The "Simplex" steriliser is arranged for small quantities. The bottles have to be closed by hand, the operator wear-

ing stout leather gloves. After the bottles have been closed they are removed and set in a bath of cold water. The "Simplex" steriliser is fitted with water connections, so that a second cooling chamber is unnecessary. Great care must be taken to admit the cold water gradually, otherwise sudden contraction of the glass will result, and the bottle and its contents will be lost.

Homogenised Milk. — Sterilisation does not prevent the butter-fat from rising. The natural flavour and character of the milk has been changed, but all the fatty constituents are still present, and in a very short time the cream will rise in the neck of the bottle and become quite solid. Where, therefore, this bottling process has been adopted with a view to supplying pure sweet milk, intended to be used, it may be, months after the sterilising, means must be taken to so incorporate the globules of fat amongst the other constituents of the milk as to prevent the cream rising, no matter how long the milk may stand in the bottles. This is accomplished by means of the homogeniser, which consists of a strong force-pump by which the milk is forced through the pores of a porcelain baffle-plate, and the fat globules are so broken up into fine particles that they do not again become detached or rise to the surface.

Cooling of Milk.

In bygone times, long before dairy farmers had become aware of the existence of bacteria, or knew anything definite as to the cause of sourness in milk, they pursued the practice of cooling milk because they found from experience that it tended to keep milk longer fresh and sweet. In our day the cooling of milk is pursued because we know that bacteria, the active agents in the souring of milk, are hindered in their development by low temperature. It thus happened that in the custom of cooling milk to a low temperature, as in many other details of agricultural practice, intelligent practical experience had long anticipated the teaching of the skilled scientist.

Milk Coolers. — An appliance for cooling milk consists of a corrugated copper plate, built so as to form a water chamber between the plates. Water passes in at the bottom, fills the chamber, and exhausts at the top. The milk from a receiving-pan flows over the outside of the corrugations and is cooled by the water within.

The *flat* cooler (fig. 668) is well suited for farm use. It may be erected on a stand, or simply hung from two brackets on the wall.

The *cylindrical* cooler (fig. 669) has lately come into use in this country, and deserves the popularity it has met with.

The *conical* cooler claims as its special feature that all the milk must pass over its entire surface—that is, a jet of milk

Fig. 668.—*Lawrence flat cooler.*

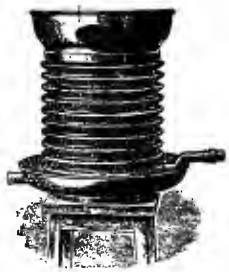


Fig. 669.—*Laval cylindrical cooler.*

cannot fall from the receiving-tray above to that below without passing over the corrugations.

Tubular Coolers.—Where the temperature of milk has to be reduced below the temperature of the water-supply in the dairy, artificial methods must be adopted in order to obtain the desired result. Refrigerating machines are installed in all up-to-date creameries, and the saving they effect during warm weather fully justifies the expense incurred.

The "Tubular" cooler is largely used for this purpose. Brine made from chloride of calcium, or a mixture of salt and rice, is reduced to a temperature below freezing-point, and circulated through the tubes of this cooler by means of a pump. The milk run over the face of the cooler can thus be reduced to any temperature between that of the water-supply and freezing-point.

Cold Store.—Where a refrigerating-

machine has been installed a cold store is almost an essential adjunct. The walls of the store, along with the ceiling and floor, may be insulated with any non-conducting material, one of the best of which is silicate of cotton. The store may be cooled by air forced over a coil in which brine is circulating, but for dairy use, brine coils, drums, or a tank, erected in the ceiling of the store, will be found to give the best results, as the cooling process continues as long as there is cold brine overhead, while with the air system the cooling process does not continue after the machine is stopped.

Refrigerating Machine.—A refrigerating machine consists essentially of a cylinder in which a gas is compressed, a coil over which water flows or which is exposed to the atmosphere, and in which the compressed gas is condensed, and a second coil in which the liquid gas is evaporated. Heat is necessary to expand the gas. This heat is obtained from whatever surrounds the coil in which the gas expands. Usually this coil is surrounded by brine, which is thus cooled in giving out heat to expand the gas. This brine is then circulated through the brine-cooler for cooling milk, or through the brine storage in the cold chamber.

The power of a refrigerating machine should be stated in the number of British

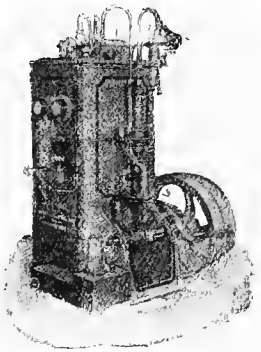


Fig. 670.—*Hall's refrigerating machine.*

thermal units which it is capable of eliminating per hour, and before installing such a plant it is well to know the quantity of water consumed in the condenser and the horse-power necessary to drive the machine. Different gases are used in working refrigerators. In Hall's refrigerating machine (fig. 670), carbonic anhydride is employed, and in Enoch's (Telford, Grier, & Mackay), shown in fig. 671, ammonia is used.

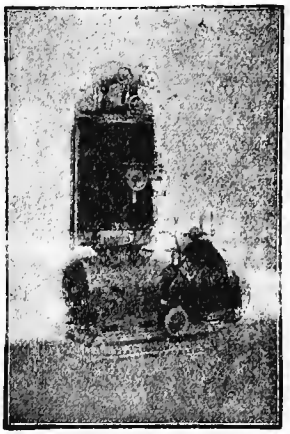


Fig. 671.—*Enoch's refrigerator.*

Condensed Milk. — The preparation of condensed milk is now quite an important industry. The process consists of evaporating the water of the milk and preserving the solids in sealed tins. The nourishing elements in the milk may be thus preserved for any length of time, but the natural flavour has been to a large extent dissipated.

DESTINATION OF THE MILK.

The treatment of the milk, from the moment it leaves the cow-house, will to some extent vary in accordance with the purposes for which the milk is to be employed—whether (1) for consumption as milk upon the farm—as human food, and for calves, (2) for selling as whole-milk, (3) selling as cream and skim-milk, (4) butter-making, or (5) for cheese-making.

It is not intended to discuss here the relative advantages or disadvantages of these various methods of utilising milk and its products. Circumstances as to supply and demand, and other conditions, may so vary in a comparatively short space of time as to completely upset former reasoning, and warrant farmers in altering their plans. Farmers are left

to decide for themselves, after due consideration of the circumstances of the particular time and locality, as to the method of utilisation that will afford them the best return for the milk. Here attention is devoted solely to describing the details to be gone through in each of the methods of utilisation pursued.

CONSUMPTION AND SELLING OF WHOLE-MILK.

When the milk is to be consumed on the farm, or sold as new milk, little manipulation in the dairy is required. In the former case it may be measured out to the consumer just as it leaves the cow-house.

In the latter case, the milk should be run over the refrigerator as soon as it is taken to the dairy. In view of a journey by road or rail, the immediate cooling process, down to 50° or 55°, is very desirable. The refrigerator should be erected so as to admit of the railway churn standing under it. A receiving-pan is erected above the cooler, into which the milk is poured from the milking-pail. Where this pan is fitted with a strainer and a circular sieve placed in the mouth of the railway churn, the milk is ready for despatch in first-class order as soon as it has been run into the churn.

Milk-selling Trade.—The selling of whole-milk for consumption in towns and villages has grown into a business of vast proportions. And as the taste for milk-food grows amongst townspeople —it is growing fast, and will surely enough continue to do so for many years —the milk-selling trade will go on increasing. In some cases the milk is conveyed from house to house by the farmer. The general custom, however, has been to consign the milk and deliver it by road or rail to extensive milk-sellers, who contract with farmers for a certain supply during the year or season.

Co-operative Milk Depots. — The central milk depot or creamery on co-operative lines has become a new feature of the dairy industry, and already several of these have been erected in important milk-producing districts, and others are in course of construction. The creameries or depots have been built and equipped by landed proprietors, and the farmers who are members of the respective co-operative associations at these centres pay rent in the shape of interest on the outlay, and have the option of acquiring the buildings and equipment on easy terms of repayment.

The milk produced on the farms of the members is brought to the depot, and as much as can be profitably sold as whole-milk is passed over the refrigerating plant with which these institutions are equipped, and thus reduced to a very low temperature to secure that it will keep in good condition during transit to the distant centre to which it may be consigned. The balance, for which there may not be a profitable sale as whole-milk, is either passed through the separator and disposed of as cream and separated milk, or partly made into butter, or alternatively made by an expert cheese-maker into a uniform high-class cheese, for which in recent years there has been a capital demand at remunerative prices, ranging from 58s. to 62s. per cwt. By this system all waste both to the producer and middleman who distributes is obviated. It is also claimed that under the system the necessity for excessive early rising on dairy farms will be obviated, as evening's milk properly cooled will suit for next morning's sales.

Methods of Milk Distribution.—In recent years marked changes have arisen in the methods of distributing milk. In cities, and even in certain villages, the milk-bottle has to some extent taken the place of the pitcher.

Milk Bottles.—Bottles for the distribution of milk are usually made of flint glass, can be sterilised, and stand a good deal of rough usage. They may be had in various sizes, from one-eighth of a pint to a quarter of a gallon. One pattern of bottle (fig. 672) is sealed with a wooden disc which fits into a groove in the neck. This disc must be destroyed in order to pour out the milk. If the discs are kept under strict charge at the dairy the milk cannot be tampered with by the messengers employed in delivery. This system of delivery is gaining in favour daily, and as it is cleanly and sanitary it should be encouraged.

Railway Milk Churn or Can.—For

transit by road or rail the steel railway-churn or can (fig. 673) is to be preferred to the oak-butts, which are still in use in some parts of the country. Cleanliness is the watchword in dairying, and in respect of being more easily cleansed the tinned-steel churns or cans have many obvious points in their favour.

Cleaning Dairy Utensils. — With this system of disposal no other dairy work is involved, excepting, of course, the cleaning of the vessels used in conveying the milk. This latter is a most important matter, which should be attended to with the greatest care. Wash and scald the utensils thoroughly as soon as they come into the dairy empty. Upon no account have any dairy utensil

Fig. 672.—*Milk bottle and wooden disc.*

dirty over-night. Where live steam is available all utensils should be scalded on a steaming-block (fig. 674) or table after being thoroughly washed. This method is particularly convenient for sterilising milk-cans and railway-churns.

Milk for Calves. — The system of feeding whole- and skim-milk to calves is dealt with in the section on Calf-rearing in vol. iii.

CREAM-RAISING.

An important piece of dairy work is the separating of the cream from the milk. The manner in which this process is carried out has much to do with the success of dairying,—more perhaps than is generally recognised.

Principles of Cream-raising.—The term cream-*raising*, which is extensively used, affords in itself an indication of the theory of the process of separating cream from milk. The factors involved are specific gravity and temperature. Cream is the lightest ingredient of milk, and therefore rises to the surface. The period of time which the cream requires to make its way to the surface depends largely on the difference in the size of the fat globules in the milk and the difference between the temperature of the milk and that of the air or water surrounding it. Water is the largest element in milk, fat the chief ingredient of cream. Water is a better conductor of heat than fat—the former expanding with heat and contracting with cold rather more quickly than fat. Thus it happens that with a falling temperature, and the water in the milk cooling and contracting—increasing in specific gravity — more rapidly than the fat in the cream, the latter is more quickly forced to the surface. On the other hand, when the temperature of the mass is rising, the difference in specific gravity between the milk and cream becomes less, and collecting of the cream on the surface therefore slower.

Fig. 673.—*Railway milk churn.*

The discovery of these facts has been of great service to dairy farmers, for it has enabled them to so manipulate the forces of nature as to raise the cream much more speedily than was attainable in former times.

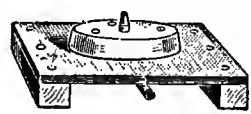


Fig. 674.—*Steaming block.*

In practice it is found that the sudden cooling of milk, as soon as it is drawn from the cow, retards the rising of the

cream, while the setting of the milk, while it is warm, hastens the process.

Methods of Raising Cream. — At one time the setting of milk in shallow pans was almost universal in this country. Now, however, several other methods of raising cream are in use, and some of them have unquestionable advantages in their favour. The deep-pan system has many advocates, and so likewise have the centrifugal separator, the "Dorset" system, the Devonshire scalding system, and the Jersey water-cooling system.

Shallow-pan System.

This system, the oldest of all, is still pursued by many successful farmers. The theory of this plan is that by setting the warm milk in pans from 2 to 4 inches deep in a cool milk-room, the temperature of the milk will rapidly fall, and thus accelerate the rising of the cream. With a steady temperature of about 58° to 60° in the milk-room, this shallow setting gives satisfactory results, raising almost the whole of the cream within from 24 to 30 hours.

Airing Cream.—It is believed that the butter made from cream raised on these shallow pans is rendered superior to what it would otherwise be by the cream being brought freely into contact with a pure cool atmosphere in the process of rising. This was confirmed by the late Professor Arnold, who stated that "cream makes better butter if raised in cold air than in cold water. . . . The deeper milk is set, the less airing the cream gets while rising."

Disadvantages of the Shallow-pan System.—The chief disadvantages of this system are—(1) that it is liable to be rendered unsatisfactory by changes of temperature in the milk-room, or if the atmosphere gets contaminated through the milk-house being in close proximity to anything giving forth obnoxious odours, such as a cattle court or dung midden, in which case the considerable exposed surface is a source of danger; (2) that it requires a great deal of shelving space for the setting of the milk; (3) that it also involves much time and labour; and (4) that the loss of fat by imperfect skimming compared with centrifugal separation is very great.

Temperature and Shallow Pans.—In the first place, if the temperature of the milk-room rise to unusual height, to anything over 60°, the milk is liable to become sour very rapidly, perhaps before all the cream has risen. Then by exposure to a temperature warmer than itself the cream is liable to absorb impurities. The importance of this latter point was enforced by the late Professor Arnold, who wrote: "While milk is standing for cream to rise, the purity of the cream, and consequently the fine flavour and keeping of the butter, will be injured if the surface of the cream is exposed freely to air much warmer than the cream. When the cream is colder than the surrounding air, it takes up moisture and impurities from the air. When the air is colder than the cream, it takes up moisture and whatever escapes from the cream. In the former case the cream purifies the surrounding air; in the latter the air helps to purify the cream."

The depth of setting, Professor Arnold added, "should vary with the temperature: the lower it is the deeper the milk may be set; the higher, the shallower it should be. Milk should never be set shallow in a low temperature nor deep in a high one."

Then if it should happen that the milk-room is unusually cold, under 50°, the milk may have to stand for 48 hours, and even then the whole of the cream may not have risen. The loss of a certain percentage of cream is not the only result of this slow rising of the cream. A great deal of shelving space must be provided for the milk, and this on a large dairy farm might involve considerable expense. Then the skim-milk will not keep so long sweet as if it had been separated sooner, while the labour in skimming and cleaning so many pans is also an item worthy of consideration.

Shallow Pans.—The pans in which milk is set in the shallow system consist of either stoneware, tinned iron, or wood. Common stoneware is the least durable of the materials employed, and is not now so extensively used as in former times. The harder and better finished varieties of stoneware are preferable.

Fig. 675 represents an excellent milk-pan made of best quality white porcelain, oval in shape, 16 inches long and 3 inches

deep inside measure. Milk-dishes of this material are wonderfully durable, nice-looking, and easily kept clean.

Fig. 675.—*White porcelain milk dish.*

The form of milk-pan now most common, and perhaps on the whole the best, is shown in fig. 676. The former has a mouth to facilitate pouring. This pan is made of tinned iron, and similar tins are made of block tin stamped in one piece, or of iron with enamelled interior, and with or without a lip to pour out the milk by. This material admits

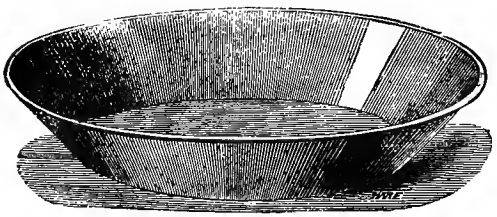


Fig. 676.—*Iron milk-pan.*

of perfect cleanliness, while it is practically unbreakable.

Zinc Unsuitable.—Zinc or galvanising should never be used on dairy utensils, except perhaps on outside parts, where the milk or its products do not come into contact with the metal. Milk always tends to sour, the souring being due, as we have seen, to the formation of lactic acid from the milk-sugar by the fermentive action of a particular

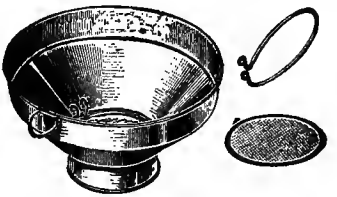


Fig. 677.—*Milk-sieve.*

germ—the *Bacterium lactis*—which is always present. The acid so formed has a great affinity for zinc, forming zinc lactate, a substance which is highly poisonous, giving rise to nausea and vomiting.

Milk-sieve.—Another utensil required in a dairy is a milk-sieve (fig. 677), which consists of a bowl of tinware, 9 inches in diameter, having an orifice covered with wire gauze in the bottom for the milk to pass through, and to detain the hairs that may have fallen into the milking-pails from the cows in the act of milking. The gauze is of brass wire, and, when kept bright, is safe enough; but silver wire is less likely to become corroded. The wire gauze is set in a tin ring,

Ready for use. Fig. 678.—*Milk filter.* Dismantled for cleaning.

so that it may be easily removed for cleansing.

The straining of the milk through a sieve such as this should in all cases be the very first operation after the milk is drawn from the cow. A very useful strainer is made for attaching to the side of the milk-pail. The use of cotton wool for straining milk is gaining favour, and an illustration of such a filter is given in fig. 678, showing how the wool may be inserted.

The creamery strainer (fig. 679) must be of suitable design to run a large quantity

of milk. If the wire gauze is inserted where the milk falls, any dirt which may collect on the surface is forced through the gauze by the next milk poured on to

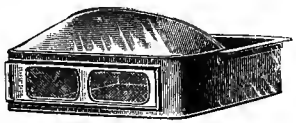


Fig. 679.—*Creamery strainer.*

its surface, so that it is better to have the gauze inserted in the sides.

Skimmer. — The creaming-dish (fig. 680), also of tin-ware, skims the cream off the milk. It is thin, circular, broad, and shallow, having on the near side a sharp edge to pass easily between the cream and milk, and a mouth is formed for pouring the cream into any vessel. At the bottom are a number of small holes for milk to pass through.

Cream-jar. — In small dairies the cream, until churned, is usually kept in a jar of stoneware or white porcelain. This should be covered by moist muslin to prevent foreign material entering.

Shelves. — The shelves in dairies should be made of materials easily and

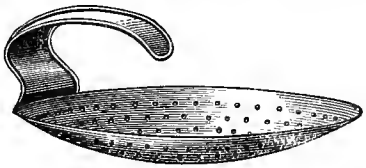


Fig. 680.—*Cream skimmer.*

quickly cleaned. Wooden shelves are easily cleaned, but are too porous and warm in summer. Stone ones are better, but must be *polished*, otherwise they cannot be cleaned without being rubbed with sandstone. Marble or slate shelving is the

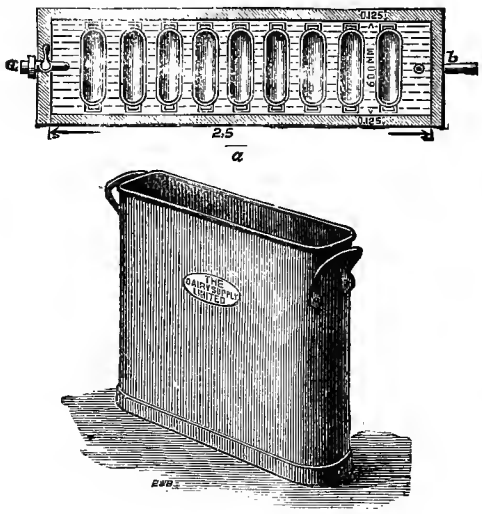


Fig. 681.—*Swartz system.*
a Trough with pans immersed in water. *b* Empty pan.

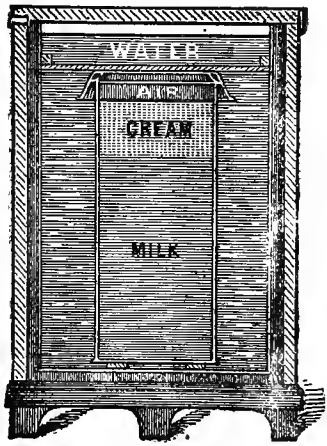


Fig. 682.—*Cooley system.*

best for coolness and cleanliness combined, and now neither is expensive.

Deep Setting.

The earliest departure from the old-fashioned shallow-pan system was the setting of the milk in deep pans.

The Swartz System.—In the Swartz system, represented in fig. 681, deep cans of milk are set in a trough filled with cold water, or water and ice, the water being kept continuously running through the trough. By these means the milk, set at blood-heat, or even warmed up higher, is rapidly reduced in temperature, and, as already explained, this falling temperature hastens the rising of the cream to the surface.

The Cooley System.—In the Cooley system, somewhat similar to, but in most

respects an improvement upon, the Swartz plan, a lid is fitted to each can on the principle of the diving-bell, so that the cold water is allowed to rise over the top. Slips of glass are fixed into the sides of the cans to show the depth of the cream, and taps are provided to run off the milk. Fig. 682 indicates the arrangement of the Cooley system.

Swartz and Cooley Systems Compared. — The main principle in the working of these two systems is the same—the accelerating of cream-raising by a falling temperature in the milk. The pans are about 20 inches deep, and in both the cream will have risen in about 12 hours. The main difference is in regard to the exposure and enclosing of the cream and milk, as to which there is some difference of opinion.

Atmospheric Influence on Cream.—In the Swartz system, as we have seen, the pans are open at the top. Some regard this as an advantage, holding that the exposing of the cream to the air has an influence which improves the butter. Others, again, prefer the Cooley system, mainly for the very reason that in it the pans are closed and submerged, so that atmospheric impurities and changes are entirely prevented from coming into contact with the milk and cream. The condition of the atmosphere immediately around is the regulating influence. Exposure to a *pure*, cool atmosphere is beneficial to cream; contact with impure, hot air is distinctly the opposite. It is therefore claimed that the Cooley system is more to be relied upon in securing uniformly good results, in spite of impurities and changes in the atmosphere.

Ice used in Summer. — For these two systems, especially in the open Swartz trough, ice has to be employed in summer unless cold spring water is available.

Advantages of Deep Setting.—The setting of warm milk in deep pans in cold water economises time, labour, and space, and lessens the risk of injury to the cream from impurities and changes in the atmosphere.

Disadvantages of Deep Setting.—The appliances are more costly than for shallow setting, and the providing of the necessary supplies of water (and ice in summer) may be troublesome and costly. The improvement imparted to butter by the free exposure of the cream, when rising to a pure, cool atmosphere, cannot be so fully obtained in the deep as in the shallow pans.

Devonshire Scalding System.

The Devonshire system of raising cream by scalding is of long standing. Fig. 683 represents the appliances employed in this system.

Method of Working.—The milk is first set in the ordinary way in pans in a cool dairy (temperature about 60°), and at the end of about twelve hours the pans are placed on a stove, as shown in the figure, and the milk scalded to a temperature of about 180°—until the surface of the cream becomes wrinkled — when the pans are removed. The milk and cream are allowed to cool, when the cream is removed and put into crocks or jars, in which it becomes thick and clotted.

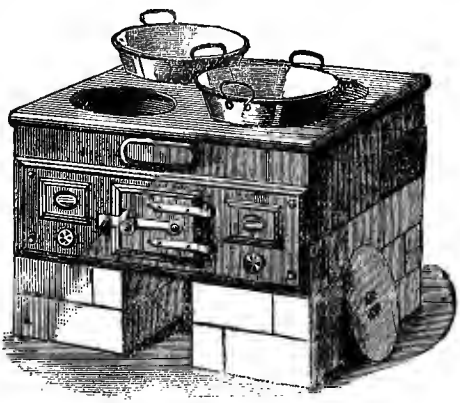


Fig. 683.—*Devonshire cream stove.*

Merits of the Scalding System.—This method of scalding raises more cream than would be obtained in the ordinary setting system. The butter is very easily made, and the scalding has the effect of purifying the cream and making it keep longer sweet.

Other Methods of Raising Cream.

There are some other useful appliances for raising cream rapidly. The "Dorset," the "Richmond," and the "Speedwell" cream-raisers are all well spoken of; the "Dorset," in particular, has been largely used with excellent results. Before the centrifugal separator was introduced the "Jersey Creamer," a very ingenious contrivance, was largely employed in some parts of the country, and is still used to some extent.

Centrifugal Separator.

The most remarkable and most useful of all the modern contrivances for separating cream from milk is unquestionably the "centrifugal separator." By the use of this admirable invention the cream and milk can be separated immediately upon leaving the cow. In recent years great improvements have been effected with the object of increasing the capacity of the machines and diminishing the already small percentage of butter-fat left in the skim-milk. Of these machines there are several patterns, all working upon similar principles. The first of them were manufactured on the continent of Europe, but several firms in this country are now turning out machines for each of which superiority is claimed.

Working of the Separator. — The milk passing into the machine is received in a bowl or cylinder. This cylinder revolves at a speed varying from 5000 to 10,000 revolutions per minute, according to the design of the machine. The specific gravity of the fat in milk is less than that of the other ingredients, consequently we find that the fat takes up a position near the centre of the cylinder with which it is revolving, and the water and solids forming the skim-milk are found close to the wall of the bowl. Tubes from this surface convey the skim-milk to the skim-milk cover, the spout of which may be turned round to a suitable position to command the can, cooler, or whatever receptacle may be provided. The cream passes up a special tube opening nearer the centre of the bowl. The design of this varies. It may take the form of a disc or other bell-mouthed structure. The essential point is that it will catch the contents of the bowl which passes upwards nearer the centre. A screw on this outlet is the usual means of regulating the quality of the cream. If the cream outlet is partly closed by the screw less milk passes out with the fat, giving a richer cream; if thin churning cream is desired, the screw may be adjusted to allow a larger outflow to pass out by the cream opening. The cream leaving the bowl is caught by a circular cover which is provided with a spout. Practically all separators are provided with a float, which checks the inflow of milk.

The less complicated gearing there is about a separator the better, provided a sufficiently uniform high speed can be maintained to effectually separate the fat from the milk. The most essential points to look for in purchasing a separator are, first, clean skimming,—not more than .10 to .15 of 1 per cent of butter-fat should be left in the skim-milk if the machine is working properly; secondly, the design of the machine, so that a maximum of speed may be obtained with a minimum of power and consequent tear and wear. Facilities for taking asunder and cleaning are also points of great importance.

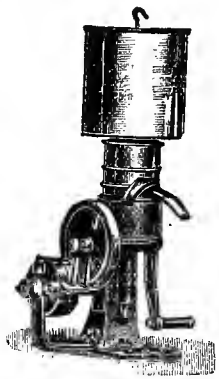


Fig. 684.—*Hand separator.*

The capacity of hand-power separators varies from 10 to 135 gallons per hour. The farmer who keeps only one or two cows for family use may have a small-sized, inexpensive machine (such as is shown in fig. 684) capable of dealing with his limited milk-supply. Many of these small machines are now being used regularly in the private dairies of country gentlemen. In the case of the larger size of hand-power machines it is sometimes desirable to have these fitted with pulleys so that they may be driven by either hand or power, if such be available.

The best machine for creamery use is undoubtedly the belt-driven separator (fig. 685). The high speed is attained by an intermediate spindle, which is complete on its own frame. This spindle is driven from the main shafting, and communicates with the separator by means of a rope drive.

The steam turbine plant answers well where a steam boiler is used. This machine is driven by a jet of steam which impinges against the buckets of the turbine wheel. This does away with the expense of an engine, but the

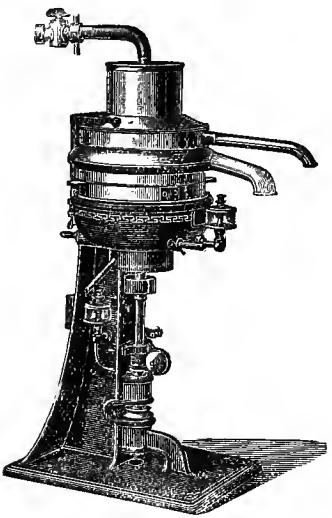


Fig. 685.—*Belt-driven separator.*

wear and tear with this style of power is greater than with the belt-driven separator.

Advantages of the Separator.—The advantages which may be derived from the use of the centrifugal separator are of great importance. In the first place, the work of the dairy is facilitated and simplified, for the setting and skimming are done away with. The cream and skim-milk are obtained separately in a perfectly sweet and fresh condition, and therefore more suitable for marketing than if the slower system of setting and skimming had been followed. All foreign matter or sediment is effectually detached from both milk and cream.

One of the chief merits of the centrifugal separator therefore is, that by its use the maximum quantity and highest quality of butter may be obtained.

Selling Cream and Skim-milk.

Since the introduction of the centrifugal separator a large and growing trade has arisen in the selling of sweet cream and sweet skim-milk.

Separated Cream.—The inhabitants of towns and villages have a keen relish for sweet cream for tea, fruit, and puddings, and the separated cream supplies this demand admirably. The cream removed by the centrifugal separator is much fresher, more wholesome, and will keep longer sweet, than cream from any of the old setting systems.

Preserving Cream.—One difficulty in the sweet cream trade is that of preventing the cream from getting sour. Various methods are tried with the view of overcoming this difficulty. The introduction of a little boracic acid into the cream has the effect of keeping it fresh longer than would otherwise be the case. But, as in the case of milk, enlightened scientific opinion is now against all forms of preservative, and dairymen and farmers must now deal with their cream just as they deal with their sweet-milk, by pasteurising and then cooling it to a low temperature, thus obviating the necessity for using preservatives.

Some dairymen adopt the more troublesome expedient of enclosing the cream in hermetically sealed tins of various sizes, containing quantities suitable for family and hotel use.

Devonshire Clotted Cream. — The system of scalding the whole-milk, which has been so long associated with the county of Devonshire, tends to strengthen the keeping properties of cream (see p. 490). The scalding destroys or impairs ferments in the whole-milk, and this followed by the cooling of the cream to a low temperature, perhaps 40° to 50°, tends to preserve the cream. This scalded cream becomes unusually thick and clotted, and is largely sold for family use in London and elsewhere. It is retailed in sealed tins, or small or large jars, which should be kept, in the shops, in suitable refrigerators.

Separated Milk.—The milk which is deprived of its cream by the centrifugal separator is no doubt poorer in a sense

than milk skimmed in the old way, for, as a rule, by the latter system, about one per cent of fat is left in the skim-milk, whereas in separated milk, as already indicated, there is rarely more than one-tenth of that quantity. But if the separated milk loses in fat it gains in freshness. It is in a better condition for selling, and for consumption both by man and beast, than if it had sat perhaps till acidity had begun.

But it should be remembered that, after all, the most nourishing and strength-giving ingredients of the milk, as it leaves the cow, remain in the milk after the cream has been removed. What it has lost in the butter-fat can be easily made up by other articles of food, and assuredly there is no more healthy or muscle-making food than plenty of fresh skim-milk. Happily its consumption amongst townspeople, to drink by itself, and for use in puddings and other food, is on the increase, though hitherto the rate of increase has not been so rapid as could be wished.

BUTTER-MAKING.

After the separating of the cream and milk, attention is given to the ripening of the cream and the making of butter. In some parts of the country, as will be afterwards mentioned, the whole mass of milk and cream is churned, but the prevailing custom is to churn the cream only.

Ripening Cream.—The importance of the ripening of cream for butter-making is not realised as it should be. Much of the bad butter made to-day in certain districts is due, not to the makers' inability to churn and make up the butter, but to lack of knowledge as to how the cream or milk should be prepared for butter-making.

In Continental dairies famed for the choicest brand of butter, the proper ripening of the cream is regarded as a matter of primary importance. If the ripened cream is as it ought to be in flavour and consistency, there need be no anxiety as to the resulting product.

To set cream aside in a foul or damp atmosphere, or in a vessel which has not been thoroughly cleansed, is to court disaster. The ripening process is effected by the action of living organisms. Foul air is laden with injurious bacteria, which will produce undesirable results, and as milk or cream forms an excellent nutritive medium for these germs, they speedily convert good sweet cream into that which will yield rancid, bitter, spongy, or discoloured butter. Hence the absolute necessity for scrupulous cleanliness and pure air.

The Use of a "Starter" or Pure Culture.—The practice of using a "starter" in ripening cream has been criticised as a "newfangled method," but it is by no means new. Butter-makers and cheese-makers in time past added buttermilk or whey to their milk in order to make it ready for churning or for the rennet. This was nothing more nor less than adding a "starter." The modern "starter" is, however, handled upon scientific principles, since it has been confirmed that bacteria are the active agents involved in producing ripe milk or cream.

In many cases buttermilk may with advantage be used; but the more reliable method is to cultivate, from day to day, a "starter," by inoculating sterilised or at least pasteurised milk with such bacteria as produce a pleasant flavour. It is usual to speak of this bacterium as *lactis acidi*, but it has been demonstrated that there are other bacteria—bacteria which at least are of different form when examined by the microscope, and which cause sourness in milk, imparting to the butter that full flavour and keeping qualities so much desiderated by the butter-maker.

These ripening agents, with instructions as to their preparation and use, should be obtained from sources that can be thoroughly relied upon.

Starter Jelly.—A suitable culture for the ripening of milk and cream, prepared in sterilised milk, so that it is ready for use, is obtainable from the Dairy Supply Company, and also from several of the leading Agricultural Colleges and Dairy Schools. The advantages which are claimed by those who advocate the use of a special culture, in the form of a "starter," are that the flavour is superior, that the keeping quality of the butter is improved, that the colour is clearer, and that the quality may be kept uniform.

Uniform Ripening of Cream.—It is very important that the mass of cream to be churned at any time should be as uniformly ripened as possible. This is most easily secured, of course, where the churning takes place daily or frequently. It can be fairly well obtained, however, by care in the mixing of the cream as it is removed from the milk. Each "creaming" should not have a separate vessel to itself unless it is to be churned by itself. The better plan is to have a cream-holder sufficiently large to hold all the cream to be churned at one time, and as each quantity of fresh cream is added, the whole should be thoroughly stirred, the stirring being perhaps repeated once or twice between the times of creaming.

As has already been explained, temperature plays a very important part in connection with the activity of bacteria, and consequently it must be kept in control by the successful butter-maker. It is now generally admitted that cream ripened at a comparatively low temperature, about 56°, gives superior butter to that made from cream ripened between 60° and 70° Fahr. In creameries where large quantities have to be dealt with daily, this may be accomplished by the use of a submerged cream-cooler, which consists of a coil of pipes through which chilled water or brine circulates. When low temperatures are adopted, larger quantities of "starter" have to be added to procure the desired acidity within twenty-four hours—a period that seems to give better results than any other in the flavour and keeping property of the butter.

The uniform ripening of all the cream in one churning is essential to obtain both the greatest quantity and the choicest quality of butter. The reason is not far to seek. Ripe cream passes into butter more quickly than fresh cream. Then with a quantity of ripe and a quantity of fresh cream in one churning the former would be over-churned before the whole of the butter-fat in the other would be transformed into butter. The result is usually a compromise, a little over-churning of the ripe cream and a slight under-churning of the fresh cream. Avoid the evils of this compromise by attending to the proper mixing and uniform ripening of the cream.

Influence of Salt in Ripening.—Salt may be added if the ripening process appears to be too rapid, where the temperature cannot be further reduced. Being a preservative, the salt retards the action of the bacteria, but it renders the buttermilk practically useless.

Sweet-cream Butter.—For immediate consumption, butter made from perfectly sweet cream is by many preferred to butter from sour or well-ripened cream. But it does not keep so well as the latter, and the weight of butter from a given quantity of sweet cream will be less by from 3 to 6 (perhaps even more) per cent than from the same quantity of sour cream.

Times of Churning.—It is a common practice to churn only once a-week. Others think it preferable to churn twice, and many do so three or four times a-week, or even daily. In the majority of cases of churning once or twice a-week, the whole of the cream then in the dairy, excepting that taken off on the previous day and day of churning, is well mixed together and churned. The fresh cream is usually held over till the next churning. The times of churning must of course be regulated by local circumstances, such as the quantity of cream to be handled and the demand for butter.

Temperature of Cream for Churning.—There is not a little difference of opinion, amongst both theoretical and practical butter-makers, as to what should be the temperature of cream when put into the churn. Fortunately, it would seem that upon this point some latitude may be allowed without seriously injuring the produce. Much, of course, depends upon the temperature of the churning-room. From 55° to 58° in summer, and from 58° to 63° in winter, are common ranges of temperature for the cream just on being put into the churn—56° to 58° in summer, and 60° to 62° in winter, are perhaps most general. Some prefer to keep the dairy at the same temperature—about 58° to 60°—in summer and winter, and so churn the cream at the same temperature all the year round.

A high temperature hastens the churn-

ing—the "coming" of the butter—but this gives pale, soft, and often spongy butter.

In the best creameries it is now found that the introduction of refrigerating machinery, facilitating experiments in churning at low temperatures, has led to the adoption of what at one time was considered a ridiculously low temperature—viz., between 45° and 50° Fahr. But still, where the churn is driven by the hand the higher temperatures are retained.

Effect of Food on the Churning Temperature of Cream.—In his experiments on the effect of food on milk and butter in the three years 1895-97, Mr Speir, Newton, found that if various foods were freely used it was necessary to churn the cream at a higher temperature than if the cows had been fed on pasture. Unless this was done, the percentage of fat left in the buttermilk was very much increased, and the time required to do the churning was considerably lengthened. The following table gives a rough idea of the range of temperature found necessary to give the best results:—

Food used.	Degrees Fahr.
Young pasture	56 to 58
Dried grains, bran, and treacle	57 " 59
Paisley (gluten) meal and grains	58 " 60
Pea-meal and grains	59 " 61
Sugar-meal	60 " 62
Sugar-meal and malt coombs	61 " 63
Bean-meal	62 " 64
Meat-meal and decorticated cotton-cake	64 " 66
Decorticated cotton-cake	66 " 68
Young heather	66 " 68

The above figures apply where the cream is sufficiently ripened, and the temperature of the air ranges from 58° Fahr. to 62° Fahr., and the cows are neither recently calved nor approaching the end of their lactation.

Churning Whole-milk.

Strange as it may seem to some, the old-fashioned system of churning the whole-milk after it is properly ripened or lappered is still practised in several parts of the country.

Advantages of Churning Whole-milk.—The chief advantages claimed for the churning of the whole-milk are, that less dairy space and milk-setting appliances are required, that in certain districts more money can be obtained for the buttermilk than for skim-milk, and that more butter is obtained than where the milk and cream are separated by skimming, and only the latter churned. There is, no doubt, a saving in outlay for buildings and utensils, and in a district where a good market can be got for the butter and buttermilk, and both can be sold from the cart, the system works well.

In all probability a little more butter may be obtained by churning the whole-milk than when the cream is skimmed off by hand, as a portion of the butter-fat is left in the milk. But with the more effective method of separating the cream by means of the "centrifugal separator," the churning of the whole-milk will not likely compare favourably, especially in regard to weight of butter.

The improved contrivances for more speedily and effectually separating the cream from the milk have removed the strongest argument advanced in favour of the churning of the whole-milk.

Disadvantages of Churning Whole-milk.—Amongst the reasons urged against the churning of the whole-milk are, that it involves a great deal of labour in churning such a large quantity of fluid, and that the resulting buttermilk, excepting in industrial districts, meets with a poor demand, and is not so suitable for calf-rearing as new separated milk. The butter made in this way is more difficult to work, and considerable skill is required to effectually remove the water and the casein, with which it has been in close contact in the churn.

The buttermilk finds a ready sale in large towns for human food, but in the country districts the demand for this purpose is of course very limited. It is useful for feeding pigs, but, as already indicated, not so suitable for calves.

Methods of Preparing Whole-milk for Churning.—In preparing the whole-milk for churning it is necessary that it should be well soured. If churned while sweet a good deal of the butter-fat may remain in the buttermilk. A little buttermilk is often poured in amongst the fresh

whole-milk to hasten its souring, but this is not a good plan, as the buttermilk is liable to contain organisms that would be detrimental to the butter.

The system which is coming largely into use is to add a "starter" as soon as the milk is set. The lapper is greatly improved by stirring it occasionally while ripening, but the milk must be allowed to coagulate. Large oak butts may be used for this purpose, as tin is apt to impart a flavour to milk which sits for some time, especially where the milk is set at milking temperature.

Continental Method.—By carefully regulating the temperature of the dairy and the depth of the milk in the butts, Continental dairymen, who churn the whole-milk, secure the proper degree of ripeness without introducing any ferment. For this purpose they keep the temperature of the milk-room somewhere between 45° and 59° Fahr. If the temperature is low, say between 45° and 50° Fahr., the milk should be filled into the butt to a depth of about 24 to 28 inches. If the temperature is higher the milk should be set shallower, so that when the maximum temperature of 59° Fahr. occurs the depth of the milk should not be more than from 12 to 16 inches.

The milk should be put into the butt just as it comes from the cow. No previous cooling is necessary, nor is it advantageous, as it retards the ripening too much. Should the butt not be big enough to hold an entire milking, the milk should be divided between two butts, but quite equally, so that the ripening may go on at the same pace in both, for unequally ripened milk makes bad butter. On no account should warm milk be added to partially ripened milk, for if that is done, bad-keeping flavours are sure to develop in the butter. If the temperature of the room rises higher than 59° Fahr. the milk should be cooled, and if it should be too cool the milk must be heated, otherwise there will be imperfect ripening and consequent loss of butter. In about thirty-six hours the milk will likely have attained the proper degree of ripeness, and then, before being put into the churn, it is thoroughly mixed, so as to be rendered quite homogeneous.

CHURNS.

How many first-class churns there are in the market at the present day one would not venture to say. Not only is the number considerable, but it goes on increasing. It is well, indeed, for the dairy farmer that his wants are thus so admirably provided for.

No attempt will be made to draw up a list of the first-class churns in order of merit, but it may be useful and interesting to illustrate and indicate the working of two or three of the well-known churns.

Types of Churns.—In general use throughout the country there are three types of churns less or more distinct: (1) those in which the fluid and the containing vessel with its agitators (if it has any) are in rotative motion; (2) those in which the containing vessel is at rest and the agitators are in rotative motion; and (3) those in which the agitators rotate in one direction while the containing vessel rotates in another.

Plunge-churn.—The old-fashioned *plunge-churn*, in which the agitator is worked by hand upwards and downwards in a stationary cylinder of cooper-work, is never seen now in a well-equipped dairy. It is still employed on some farms where dairying receives little attention, and where few dairy improvements have been introduced. It is heavier to work, and altogether inferior to the modern barrel churns.

Fig. 686.—*End-over-end churn.*

Barrel Churns.

End-over-end Churn.—The end-over-end churn (fig. 686) is widely popular with up-to-date butter-makers. The

mouth is large, admitting of easy cleansing, while there is no inconvenience with a leaking joint. The grain of the butter made in the end-over-end churn is as near perfection as it may be obtained in any other pattern. The construction is simple, and consequently a real serviceable churn may be had of this type at a reasonable price.

It is important to notice that churning operations are greatly retarded if an end-over-end barrel churn is more than half full; indeed it is advisable not to fill the churn more than one-third full.

Diaphragm Churn. — Messrs Bradford & Co. have fitted a special appliance in the form of beaters or breakers inside their churn, so that the diaphragm churn of to-day (fig. 687) is simply an "end-over-end churn" with breakers fitted longitudinally in the interior.

It is claimed for this churn that the time of churning is shortened while the grain of the butter is not inferior to that obtained in the simple barrel churn.

Other Forms.

Holstein Churn.—The Holstein churn is an example of the third class of churn mentioned. It is an upright barrel, with agitators which revolve horizontally while the churn is at rest. The Holstein churn is extensively employed in large factories and creameries, where a number of churns require to be driven separately from one shaft.

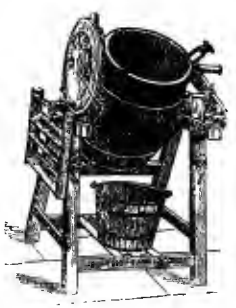


Fig. 687.—*Diaphragm churn.*

Streamlet Churn. — This churn, made of fire-clay enamelled, is extensively used for churning the whole-milk in the west of Scotland. It is usually made in large sizes, with dashers. It is rather difficult to clean out, and for this purpose steaming is most effective.

"Speedwell" Crystal Churn.—This churn consists of one or more glass jars or cells, mounted in a revolving frame —a frame adapted for sitting upon a table (fig. 688). This churn is very convenient for churning small quantities of cream in private dairies, or for experimental purposes.

Swing Churn.—This churn is in the form of a box or child's cot, and effects the churning by oscillation.

High-speed Churns.—From time to time various designs of high-speed churns, such as the Disc and Fishback, have been introduced, claiming to reduce the time of churning from thirty to three minutes, and at the same time to produce the choicest butter. These churns, however, have not met with the general approval of butter-makers, and it may therefore be doubted whether the high-speed principle is adapted for so delicate a product as butter. The high-speed churns are liable to leave an exceptionally large percentage of fat in the buttermilk.

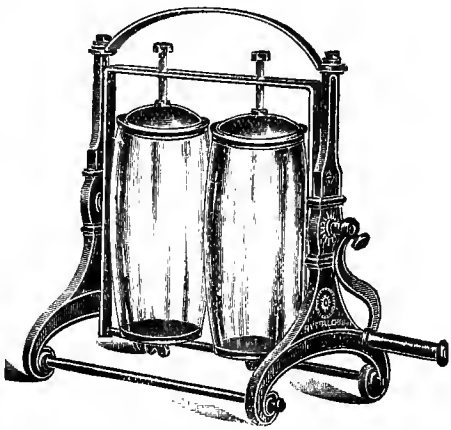


Fig. 688.—*Speedwell crystal churn.*

Factory Churns.—With the development of butter-factories in this country the demand for churns to deal effectually with large quantities of cream has increased. In order to meet this demand makers of dairy appliances have departed from the design of hand churns. The factory churn (fig. 689) most commonly used is simply a large cylinder built of wood, with a spindle passing through the centre from end to end. To this spindle is attached two or more beaters. The churn is erected in a horizontal position and the beaters driven by a belt from the dairy shaft. In one end there

is fitted a large door through which the buttermilk with the butter is drawn off into a tank in which the butter may be washed, and from which it may be easily transferred to the butter-worker.

Combined Churn and Butter-worker.—The latest and perhaps best

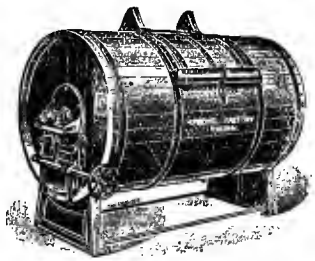


Fig. 689.—*Factory churn.*

device is in the form of a churn and butter-worker combined (fig. 690). Here, after churning is completed, rollers are placed in position within the churn. The churn is then set in gearing, which causes the barrel to revolve; this carries round the butter, which drops between the rollers, and is pressed together while the water is worked out. The advantage of this arrangement is that the loss of butter is reduced to a minimum, no grains being lost on the way from the churn to the butter-worker, or carried away with the buttermilk.

Important Features in a Churn.—While the farmer may exercise consider-

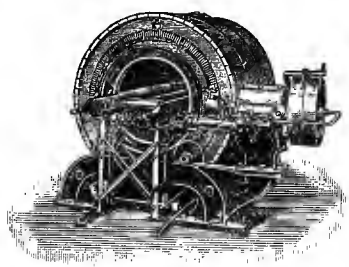


Fig. 690.—*Combined churn and butter-worker.*

able freedom in the choice of the pattern of churn, there are a few important features which he should look for and insist upon. Amongst these are, that the churn should be easily cleaned, with no crevices wherein dirt may lodge and escape observation; that it should afford ample facility for removing the butter; that the churn may be easily ventilated; and that means should be provided for seeing the cream and ascertaining its temperature during churning. Light working as well as efficiency should, of course, also have due consideration.

It is a good plan to have a small pane of glass in the churn through which to note the progress of the churning. And to permit the escape of gases evolved in the process of churning, there should be a ventilation valve in the lid of all churns.

Churning.

The details of churning have now to be dealt with. These require little explanation.

Preparing the Churn.—The preparation of the churn for the reception of the cream requires careful attention. It may be assumed that, after the previous churning, it had been thoroughly cleaned—first rinsed with cold water, then well scalded with boiling water, and again rinsed with cold. If it has not been in use for a few days, the churn may be scalded with hot water the day before churning. Some heat the churn with hot water just before putting in the cream. Others consider this a bad plan, and prefer to rinse out with water about the same temperature as the cream, or perhaps even two or three degrees lower than the cream. In cold weather the churn is heated, and in hot weather cooled.

Upon the whole, perhaps the safest plan is to have the temperature of the churn just the same as that of the cream to be churned. The temperature of the cream rises a little, about 3° or 4°, with the friction in churning.

Some sprinkle a little salt in the churn before the cream is put into it, and others put salt into the water used in rinsing. The object of this is to counteract any taint that may possibly be present.

Straining Cream.—To prevent, as far as possible, impurities getting into the milk, the cream is run into the churn through a strainer, perhaps a coarse linen cloth, well known as cheese-cloth. This cloth is dipped in clean water, and held over the mouth of the churn while the cream is poured into it. The thickest

of the clotted cream will be held back, and impurities, such as dust and flies, will be prevented from getting into the churn.

The straining-cloth is washed without soap, and kept sweet by exposure to air.

Speed of the Churn.—The speed at which the churn and agitators, if there are such, should be driven depends entirely upon the design of the churn. The end-over-end pattern should be driven about 60 revolutions per minute.

With very slow churning the butter is long in coming. With rapid churning the butter is liable to be soft and oily. With every individual churn, and in the varying circumstances of temperature and condition of the cream, the operator must exercise careful judgment as to the rate of speed in the churning.

Ventilation.—This must be carefully attended to in the first 8 or 10 minutes' churning. In the stirring of the cream at the outset, some gas is evolved, and the ventilator in the churn should be opened frequently during the first 10 minutes, to provide the desired ventilation.

Breaking Water.—When the butter "begins to come"—*i.e.*, when the butter is just forming a grain—it is advisable to add a small quantity of water. When added, the temperature of the water should be at about 10° below that of the cream. This addition of water assists in securing a granular condition in the butter, and restores the temperature to nearly the original temperature of the cream.

As soon as the granules become about the size of shot, or about ⅛ inch diameter, churning should be stopped, the buttermilk drawn off, and the washing water added. This is a point when care should be taken to remove the last traces of buttermilk. Change the washing water until it is drawn off quite clear. A solution of ordinary salt may be added to assist in removing the buttermilk.

Time Churning.—The churning will probably have occupied from 30 to 40 minutes. With less time, there is a liability to softness in the butter, and great risk of an excessive amount of fat being left in the buttermilk, while with much more time the flavour is apt to be injured. During the time of churning, the agitation will raise the temperature by perhaps 3° or 4°.

Sleepy Cream. — Occasionally the complaint is heard from the dairy that "the butter won't come," "the cream is sleeping." Most probably the cause will be that the cream is too cold. Test the temperature with the thermometer, and if it is below 55° in summer, or 58° in winter, raise it to slightly over these points by immersing a vessel filled with hot water (fig. 665).

But the temperature may be high enough and still the butter, or a portion of it, may refuse to come. In this case also, scalding the cream may be effective. If not, the use of a little churning powder, which it is well to have at hand, will most likely make the sleepy, frothy cream give up its butter. Dr Aitken considered a little bicarbonate of soda (baking soda) as efficacious as any butter-powder.

This difficulty is most liable to occur in the cold months of the year, and may be due to various causes besides cold cream, such as the feeding of the cows, a sickly cow, dirty milk-vessels, or to cream from cows that have been long constantly giving milk.

Butter-working.

The working of the butter is part of the operation which demands the most careful attention in its minutest detail.

Object of Working.—The object of working the butter is the complete removal of the superfluous water, the working-in of the salt, and the consolidation of the butter into a solid mass. This should be done by pressure, not by rubbing, in order to avoid injuring the "grain" of the butter. If any portion of casein is left in the butter, it will speedily ferment and spoil the butter. Good keeping butter must be free from casein; and, to obtain this, butter-makers cannot be too careful.

Hand-working Objectionable.—Many eminent authorities state emphatically that in all the process of working, butter should never once be touched by the bare hand. The temperature of the hand is usually so high as to have a tendency to make the butter soft, while

there is also some risk of the flavour of the butter being slightly injured by contact with the hand. It is no doubt true that a great deal of first-class butter is worked by the bare hands of the operator, yet the safest plan, unquestionably, is to avoid this practice, and use some of the modern butter-workers. With one of these and the deft use of the "Scotch hand" (fig. 691) there is no need to let the bare hands touch the butter.

Fig. 691.—*Scotch hand.*

If in any case the bare hands are to come into contact with the butter, they should be first washed with warm water and oatmeal, and then rinsed in cold water, and this rinsing should be done frequently while the hand-working proceeds. A person with hot clammy hands is not suited for dairy work.

The Butter-worker.—In all well-equipped dairies the butter is now worked by a "butter-worker," such as in fig. 692. With this appliance the butter is never touched by the hands. The butter, taken from the churn in a granular state, is placed in the trough of the worker and the roller passed over it. The pressure removes the water and forces the grains into a solid mass. The butter

Fig. 692.—*Butter-worker.*

is then rolled up by reversing the motion of the roller, and placed at right angles in the trough to its former position. The roller is again passed over the butter, and this process is repeated until the butter is dry enough to be made up. Over-working at this stage must be guarded against, or the result may be greasy butter.

Circular butter-workers fitted for power are in use in large dairies.

Salting Butter.—The method adopted most generally in dairies and factories is that of dry-salting. After the roller has been passed over the granular butter once or twice the dry salt is sprinkled over the surface of the butter as it lies spread out over the worker. Working then proceeds as usual; but it is an advantage to stop before all the water has been removed, and allow the butter to lie for several hours in a tub of cold water. This allows the salt to dissolve before the final working, which of course facilitates the thorough incorporation of the salt with the mass of butter. Here, again, care must be taken not to overwork the butter, or the grain and texture will be impaired and it will have a greasy appearance.

The quantity of dry salt used for incorporating with the butter is rarely more than ¼ to ½ oz. to the pound, according to taste and length of time it is to be kept. Formerly, cured butter was much more heavily salted, but the taste nowadays is all in favour of milder salting. Even when it is to be used as fresh butter, a very little salt will improve the flavour of the butter.

Centrifugal Butter-drier.—This is an ingenious invention in which centrifugal force is employed to remove superfluous moisture from the butter. It is named the "Normandy Délaiteuse." The butter, after leaving the churn, is, while still in a granular state, placed—about 16 lb. at a time—in a canvas bag. This bag is then put into a metal cylinder, perforated with holes, like a colander, which, from motion communicated by the horizontal spindle, is made to revolve rapidly —700 to 800 turns per minute. The buttermilk, and any other moisture the butter may contain, is driven off to the circumference, and thence through the holes into the outer case, whence it passes out by the pipe into a receptacle underneath, the butter remaining in a perfectly dry condition, in immediate readiness for being worked up into pats of whatever shape may be required. The whole operation only takes four minutes, and directly one lot of butter is dealt with another may be put in.

The machine is similar to the hydro-

extractor of laundry fame; but it has not proved a success in dairying.

Scotch Hands.—Scotch hands are used for making up the butter into bricks or prints; and where quantities of over 1 lb. are to be made up, it may be done conveniently by butter-beaters. For rolls a board is more serviceable. A "Scotch hand" is represented in fig. 691.

Packing into Crocks.—If the butter is to be kept for a considerable time, it is packed into crocks. And the packing process requires both skill and care. The object is to thoroughly exclude the air, and this will be effectually secured by packing the butter in shallow layers, not much over an inch in thickness. It is a good plan, after placing the first layer in the bottom of the crock, to line the sides with a similar layer as high up as it is intended to fill the vessel. Then proceed to press in one layer after another. Over the butter place a muslin cloth, and cover this with fine salt to the depth of about 1 inch.

To this covering some prefer to have about an inch deep or more of brine floating on the top of the butter. By this method, always taking care to keep the surface of the butter covered with brine, the writer has kept butter, which had been given merely a trace of salt in the working, quite fresh, from the beginning of October in the one year till into May of the following. Even at the very last the butter was perfectly free from any rancid or undesirable flavour, and was so slightly salt to taste as to almost pass for fresh recently made butter. But this butter was made by a skilled hand, who was careful to leave in it the least possible traces of casein, which is so destructive to the keeping properties of butter.

Fresh Butter.—If butter is properly made from pasteurised well-ripened cream, well washed in the churn, and worked so as to have the surplus moisture removed, it may be kept sweet and fresh for eight or ten days without any salt whatever. Care should be taken to keep fresh butter in a cool temperature. In warm weather the farmer should have the butter made and conveyed to market at night or early in the morning; and in retail shops refrigerators should be provided for holding the fresh butter in summer.

Butter Boxes for Transit.—Attractive and convenient boxes are supplied by vendors of dairy appliances for conveying fresh butter to market or to private consumers by post or rail. In some of these boxes there are ingenious contrivances for keeping the butter cool.

If the housekeeper discovers that her supply of fresh butter is likely to become rancid before being used, she will find it a good plan to pack the butter firmly into some fine glazed stoneware vessel and pour some strong brine over it.

Colouring Butter.—A rich golden colour is most esteemed in butter. When it is naturally pale or not sufficiently "gilt-edged" it is a common practice to colour it artificially. This may be done by introducing a little liquid annatto into the cream just before churning is commenced. Experience is the best guide as to the quantity needed to give the required tint to the particular make of butter.

But artificial colouring, like the introducing of preservatives, is an objectionable practice, and where high-coloured butter is desired, the better plan is to have on the farm one or two cows known to produce high-coloured butter. Jersey and Guernsey cows are noted for this property, and one of these will most likely give sufficient "colouring" to the butter of ten or twelve other cows.

CHEESE-MAKING.

The systems of cheese-making pursued in this country are numerous. It is a more intricate process than butter-making, affording scope for the exercise of greater skill in manipulation, and of more ingenuity in producing differences in the manufactured article.

In making the hard cheese of this country the whole-milk as it comes from the cow is dealt with. In making Stilton cheese a little extra cream is usually, and ought always to be, added. The cheese-maker has thus a bulky article to handle, and one which requires to be handled with the utmost skill and care if uniformly good results are to be obtained.

Apartments for Cheese-making.—In well-equipped dairies there are at least three separate compartments for cheese-making—(1) the making-room, (2) the press-room, (3) the curing- or ripening-room. A convenient arrangement is to have the curing-room over the other compartments, or over the press- and making-rooms only. Some prefer to have the curing-room on the ground-floor. An important point is to have this room, and indeed all the compartments, protected as much as possible from variation in temperature, and so arranged that the temperature can be controlled summer and winter. For this reason all curing-rooms, whether on the ground-floor or higher, should have a ceiling as some protection against rapid changes of temperature. The floors of all the rooms, other than the curing-room, are usually of some material which is impervious to water, preferably of good concrete with a smooth surface. The walls may be plastered, cemented, or lined with enamelled tiles. The ceilings, unless where there is considerable vibration, are plastered. Ceilings lined with wood are sometimes a cause of trouble in dairying, as they allow particles of matter to pass through. All drains inside the buildings must be open or surface drains, and where these reach the outside of the walls they must be well trapped, the traps being covered by a grating only.

As in butter-making, the apartments and all appliances and utensils must be kept perfectly clean and fresh. Bad odours and impurities in the milk are fatal to successful cheese-making.

Utensils.—The utensils required in cheese-making are numerous, though few of them are costly. They include, besides the ordinary milk-pails, &c., a milk-vat or tub, strainers, dipper, curd-knives, rake, cooler, draining-racks, curd-mill, curd-shovel, cheese-moulds, hoops or chessets, and cheese-presses. The curing-room is usually fitted with turning shelves, so that two or three shelves, with their contents of cheese, turn round on an axle.

The Vat.—The vessel in which the milk is collected to be coagulated by rennet is called the cheese-vat, or cheese-tub. It is usually oblong, as shown in fig. 693, and mounted on wheels, so as to be easily moved about, and from one room to another. Vats are made of many sizes to suit different dairies. Modern vats have a double casing, so as to admit between the two cases cold water for cooling, and hot water or steam for heating the milk or curd. The inner case should be of the best tinned steel. The vat is provided with a large brass tap for running off the whey, and with smaller taps at different levels for running off the cooling and waste water. Formerly the milk-vat took the form of a circular tub without the double casing, and the milk and curd could be heated only by removing a quantity of the milk or whey, scalding it to a high temperature, and pouring it back into the vat. This was a troublesome operation, and had to be frequently

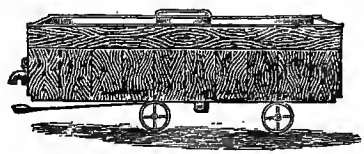


Fig. 693.—*Milk-vat.*

repeated. In the modern vats with double casing the contents can be heated to any desired temperature by circulating steam or hot water between the two cases. In the same way the evening's milk can be cooled in the vat by the use of cold water. With the round tubs cooling of the milk could be facilitated only by stirring the milk in the vat, or by exposing the bulk of it in shallow pans. The almost perfect control of the temperature of the milk and curd which the modern cheese-vat gives, is of great importance in the making of uniform cheese.

Curd-mill.—The frame of the curd-mill (fig. 694, Pollock's, Mauchline) is of wood or iron, and consists essentially of two horizontal bars supported firmly on four legs. Firmly held between the two bars is a metal grating. Running along the middle of the grating is a regular open space, into which is fitted a revolving iron axle with two or three rows of pins or teeth fixed in it spirally. A wheel with a handle drives the toothed axle, and one tooth of each row passes

through each bar of the grating. On the top is fastened a hopper with hinges. The curd is put into the hopper in slices, is cut and broken by the toothed axle in passing through the grating, and falls into the receiver below. The object is to tear the curd into pieces to receive the salt, and facilitate the removal of free moisture in pressing, but not to reduce the curd to pulp and render it greasy, as with many of the older machines.

Fig. 694.—*Curd-mill.*

Presses.—The varieties of cheese-presses are numerous. The more common forms at the present day are fitted with levers, from the simple lever to the combination of lever and toothed wheel, and the double levers (figs. 695 and 696). The essential feature of a good cheese-press is that the load descends automatically after the cheese, which sinks as the whey is expelled. Each press should be capable of giving a pressure of at least 30 cwt.

Rennet. — Rennet is the agent universally employed in cheese-making to coagulate the milk. It contains as its chief constituents the enzymes "rennin" and pepsin. The ferment rennin is found in the gastric juice of all mammals, and specially in the young while still suckling. Rennet is commonly prepared from the mucous membrane of the fourth stomach of the calf. Healthy stomachs are selected, dried, and kept for some time. They are next cut into small pieces, and put into a 5 per cent solution of common salt containing a little boracic acid. After some days a further 5 per cent of salt is added, and the liquid filtered. The clear liquid is extract of rennet. The general practice is to use one of the commercial extracts of rennet, which are now to be obtained of uniform strength and at moderate prices. The strength of any sample of rennet extract can readily be compared with rennet of known strength by adding the same measured quantity of each to two equal quantities of milk taken from the same bulk under the same conditions, and comparing the time that elapses in each case before coagulation becomes evident.

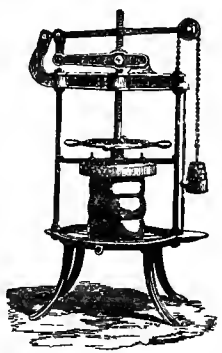


Fig. 695.—*Single cheese-press.*

Action of Rennet.—The action of the rennet enzyme on milk is to produce a fermentation, whereby the caseine

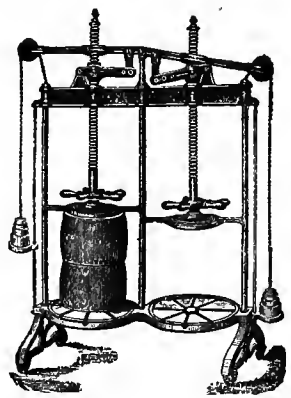


Fig. 696.—*Double cheese-press.*

which is present in partial solution in combination with lime becomes in large measure precipitated in the form of a clot. This clot mechanically encloses and holds most of the fat globules, and forms the curd. The pepsin of the rennet, aided by acidity, plays a most important part in the ripening of the cheese.

Rennet acts only in neutral or acid solutions, and its action is affected by the acidity in milk. The greater the acidity the more rapid its action. Like other enzymes, its action is also dependent on temperature. It acts best at about 105° Fahr. Near this temperature the curd produced is firm, at low temperatures soft and flocculent. Heating rennet to 140° or over causes it to rapidly lose its properties. Milk which has been heated to this temperature and

cooled does not coagulate properly with rennet, owing to the rendering insoluble of some of the lime salts. The addition of soluble lime salts to such milk causes it to curdle with rennet in the usual way.

Acidity. — Acidity has a most important and far-reaching effect in the making of cheese. The manufacture of quantities of uniformly fine cheese necessarily implies the successful control of the acid development in the milk and curd at the different stages of making. In the Cheddar system a certain degree of acidity is absolutely essential to success. Unless the milk is allowed to become sufficiently acid before adding the rennet, and the curd before salting, coagulation will be imperfect, the curd obtained will be soft and flocculent from lack of acid to assist in the cooking of the curd, the cheese will develop a bitter flavour for want of the acid, which tends to purify the milk and curd, and from the presence of excess of moisture, the cheese will not become properly ripened or digested through lack of the acid which is necessary to the action of the digesting pepsin, but will remain tough and leathery in texture, and the cheese during ripening will become distended by the development of strong-smelling gases.

Too much acidity is also injurious in a cheese. It will injure the texture and make the flavour too sharp. Such a cheese will be dry and crumbly and not sufficiently mellow. In poor milk less acidity should be developed than in rich milk. For this reason the acidity is kept more moderate in spring than in summer or autumn. Acidity has much to do with the rate of ripening and the keeping properties of a cheese. If too much acidity has been developed the cheese will ripen quickly but will not keep well. With little acidity a cheese ripens slowly, usually develops undesirable qualities, and cannot be said to keep well. The best keeping cheese is one which has the proper degree of acidity developed. For the best results about 1 per cent of acid is necessary in the curd when salted.

Ripening.—The acid which develops naturally in milk and curd is lactic acid, and is the product of bacteria in lactic fermentation. This fermentation is brought about by the important class of organisms termed lactic bacteria. Part of the milk sugar becomes converted into lactic acid, which gives a sour flavour to milk, and in time coagulates it. The development of lactic acid, being a bacterial change, can be controlled by regulating the temperature of the medium; so that temperature is one of the most important factors in successful dairying. Cooling the evening's milk and holding it at a low temperature overnight retards acid development. Heating milk to 80° or 100° Fahr. greatly hastens this change. The development of acidity in milk can also be greatly hastened by the addition of a "starter." Adding a starter is a method of inoculating the milk with large numbers of bacteria, and ensuring that the milk is thickly seeded with the germs necessary for lactic acid production.

"Starters."—Starters used in this way are either home-made or culture-starters. The former include sour whey, sour cream, buttermilk, and milk which has been allowed to sour under natural conditions. In most cases such starters are more or less impure, containing some species of bacteria which bring about undesirable changes in the milk and curd, and give rise to various defects in cheese. The method, once common, of ripening milk by mixing with it a little sour whey is not to be recommended. Mr Drummond, of the Kilmarnock Dairy School, preferred to this system that of developing acidity naturally in the milk by regulating the temperature, by having the evening's milk cooled, so that sufficient heat is left in it to develop by morning the degree of acidity required. The warmer the milk overnight the more rapidly it becomes sour. It was generally found that sufficient acid was developed when the evening's milk was at a temperature of from 66° to 70° in the morning. No doubt a little pure sour whey, judiciously used, gave better results than making cheese with too little acidity in the curd. Since the introduction of culture-starters, however, better and more uniform quality can be obtained from their use in cheese-making than from any of the older methods of ripening milk.

Culture-starters. — It is usually a matter of chance as to what kinds of bacteria a home-made starter will contain, and of late years the use of pure culture or commercial starters has become almost general. A pure culture is a culture of a single species of bacteria in an artificial medium. The species is selected on account of its ability to produce a desirable ripening in milk and curd, and is cultivated and sold commercially by bacteriologists in the form of a liquid or a powder. The powder forms are to be preferred. The principles of pure culture ripening are—(1) the elimination as far as possible of the bacteria usually present, by strict attention to cleanliness so as to prevent unnecessary contamination of the milk, and by cooling the milk as quickly as possible after it is obtained, to check the growth of the bacteria present; (2) the addition of a large number of the desirable germs to start the proper fermentation, and to enable these bacteria to gain the ascendancy over the other species present.

Important advantages have accrued during recent years from the use of culture-starters in cheese-making in the south-west of Scotland. The quality of the cheese is more uniform than formerly, and of a higher standard of merit, due largely to the more regular control of the ripening processes.

The credit of having introduced these culture-starters for cheese-making into this country belongs to Mr Drummond. He was of opinion that many of the defects then common in Cheddar cheese—such, for example, as discoloration, a trouble then very prevalent, and causing great loss in the south-west of Scotland—were due to the development of undesirable organisms in the ripening milk overnight, and that the keeping of this milk at lower temperatures, followed, in the morning, by the addition of quantities of culture-starter containing the desired organism for ripening, would produce a purer fermentation in the ripening curd. The use of culture-starters in this way was subsequently greatly extended through the influence of the itinerant instructors in the counties of Ayr, Kirkcudbright, Wigtown, and Dumfries.

Propagation of a "Culture-starter." —The culture when received should be fresh and the seal unbroken. In old cultures the germ may have died out. The whole of the powder is added to about half a gallon of freshly pasteurised skim-milk at a temperature of 80° Fahr. The vessel is laid aside, covered with a clean muslin or cheese-cloth, in a suitable part of the dairy, until the milk has become partially coagulated, which, under ordinary conditions, will be in about 18 hours. This process is repeated daily, some of the previous day's starter being used to inoculate the next lot of milk. The quantity of starter used for propagating in this way is about 10 per cent, or 1 lb. of starter to a gallon of pasteurised milk. The vigour of the starter for the first few days daily increases, and all starters should be thus "built up" for a few days before being used in the cheese-vat. A starter should at no time become completely coagulated, but only partially so. Too much acidity diminishes the vigour of a starter. To prevent over-development at any time, dilute with freshly pasteurised skim-milk. Commercial starters may be propagated as long as they retain the pleasant acid flavour and smooth appearance, and give no indication of the presence of gassy or other unpleasant odours. For those who have little experience of starters a safe rule is to obtain a fresh culture every two weeks.

Controlling the Acidity.—The controlling of the acidity is unquestionably one of the most important and most difficult points in the entire process of making. It is important that exact knowledge be acquired, not only of the part which acidity plays in the making and maturing of cheese, and the means by which it may be developed, but also of how it may be measured and controlled. The most rapid development of acid in cheese-making takes place in the milk just before coagulation. After coagulation the acid formation is considerably checked by removal of moisture from the curd, as the more moisture contained in curd the more rapid the acid development. Early renneting of the milk and cooking of the curd both tend to retard ripening. After renneting the most rapid ripening takes place just

before drawing off the whey. The cooling of the evening's milk, the adding of the starter, the renneting, the drawing of the whey, are all important methods of controlling the rate of acid development. Other important factors influencing the ripening are the salting and pressing of the curd, and the temperature of the curing-room.

Measuring the Acidity.—The acidity in milk or whey can be measured fairly accurately by the acidimeter. This is a simple and reliable guide in competent hands as to when to draw the whey. Unfortunately, the testing of milk for renneting is not such a simple matter, as the comparatively large and variable quantity of carbonic acid (carbon dioxide) present in the milk at this stage affects the reading, causing it to vary considerably and be unreliable. The subsequent heating of the whey drives off most of this acid gas before the whey is drawn. The most reliable guide at present as to the time of renneting is the rennet test. This is a comparative test only for comparing the acidity in the milk one day with another. It is based on the principle that, other conditions being equal, the greater the acidity the more quickly will milk coagulate with rennet. Four ounces of milk at 84° and one drachm of rennet extract are employed, and the time that elapses before coagulation becomes evident noted.

Perhaps the most reliable and simple test for acidity in curd is the hot-iron test. It is found that acidity has the effect of partially digesting the curd, so that it will string or draw out in fine threads from a hot iron. Within certain limits, the longer and finer the threads the greater the acidity in the curd. This test is a convenient one for all cheese-makers, and in the hands of an experienced person reliable results are obtained.

The methods pursued in making different varieties of cheese will now be dealt with in detail.

CHEDDAR CHEESE.

The Cheddar variety of cheese, which takes its name from the village of Cheddar in the county of Somerset, has been well known for centuries. It was introduced into the south-west of Scotland by the late Mr Joseph Harding, Marksbury, Bristol, who is said to have been the first to establish the practice of Cheddar cheese-making upon a regular system. It is now extensively made in that part of Scotland, as well as in Somersetshire and other districts of England. It is also manufactured in very large quantities in Canada and the United States.

The making of Cheddar cheese has received very special study in Canada, and it is remarkable that the employment of Canadian specialists as instructors led to great improvement in the system of Cheddar cheese-making in the south-west of Scotland. Subsequently the Scottish Dairy Institute was established at Kilmarnock, under the management of Mr Drummond, and this school of dairying has had a remarkable influence on the cheese-making not only of Scotland but of the United Kingdom. In more recent years the extension work done by itinerant instructors in the south-west of Scotland, under the joint auspices of the West of Scotland Agricultural College, the various County Dairy Associations, and County Councils, has also been the means of greatly raising the quality of the cheese of these districts to a higher and more uniform standard. The position which Scots Cheddar now occupies on British markets is well exemplified by the fact that cheese from Scotland has in several instances gained the bulk of the premiums at the London Dairy Shows, besides securing valuable prizes at other important English dairying centres.

Character and Composition of Cheddar Cheese. — Before giving the details of the operation of Cheddar cheese-making, it will be well to define as clearly as possible what a typical Cheddar cheese is. Cow's milk, with which we have to deal in cheese-making, usually contains about 13 per cent of solids and 87 per cent of water. Cheese-making is the process of preserving the valuable food solids of milk in the best possible form as human food. A Cheddar cheese, speaking generally, is composed of about equal parts of butter-fat, caseine, and water, with a small proportion of sugar and mineral matter. A good cheese has

a quality rich and mellow, a characteristic pleasing flavour, a uniformly close smooth texture, a bright even colour, and a prepossessing attractive appearance. "Quality" in cheese may be defined as the nature of the inherent properties, considered relatively. Thus a rich mellow cheese is of good quality, a hard dry cheese of poor quality. Texture refers to the arrangement of the matter composing the cheese. Thus a cheese is either smooth or rough in texture, according as the compound particles are combined to form a smooth or grainy body of cheese, and open when the pieces of curd, after pressing, do not form a completely solid mass in the cheese. The colour of a cheese may be defined as the quality that affects our senses with regard to its hue or tint. The colour of a cheese is true when the body of the cheese after being cut appears of exactly the same colour throughout, and untrue when the body of the cheese has a mottled or streaky appearance. The appearance or finish is seen on the outer surface. In a cheese this should be considered good or bad according as it is symmetrical in shape, with a smooth clean skin, or unshapely, and with a surface dirty, cracked, and open.

Scale of Points.—The following scale of points of merit is that adopted by the Ayrshire Agricultural Association at their great annual Cheese Show at Kilmarnock: Flavour 40, body and texture 40, colour 12, appearance and finish 8.

Character of Milk.—As has already been shown, milk has a natural tendency to decay, as it offers very favourable conditions for the rapid growth and multiplication of many different species of bacteria. These readily gain access to it in large numbers from the surroundings generally, even when special precautions are taken in regard to cleanliness. And when strict cleanliness is not observed, the introduction of impurities in this way is sure to affect the flavour and other valuable properties of cheese prejudicially. Thus too much care cannot be taken to protect the milk as far as possible from all contamination.

Treatment of the Milk.—In Cheddar cheese-making the evening's milk is kept in the vat, to be mixed with the warm milk in the morning. Besides keeping it where the surroundings are fresh and pure, it is important that the evening's milk be properly cooled. The aim, where a starter is employed in ripening the milk, is to keep the evening's milk as fresh and free from all germ action as possible, till it can be inoculated with the starter in the morning and mixed with the morning's milk. This is accomplished by rapid and thorough cooling of the milk in the double-jacketed vat. It should be remembered that early cooling is much more effective in checking germ action than later cooling even to a lower temperature. The aim should be to reduce the milk to about 72° Fahr. as soon as possible after it leaves the cow. The method when no starter was used was to cause the milk to cool gradually from its natural heat to about 68° in the morning. It was then usually in proper condition to be mixed and ripened with the morning's milk without the addition of any form of starter. But when kept warmer than this the lactic acid was in most cases too far developed in the morning to allow sufficient time for the proper cooling and working of the curd.

If the milk has been properly cooled the previous evening, it will be at from 62° to 66° Fahr. in the morning, and the mixed morning and evening milk will require for proper ripening about ¼ or ½ per cent of starter. This is added early in the morning, as soon as the temperature of the milk has been noted and the cream which has collected on the surface removed and again mixed with the milk. The quantity of starter is carefully measured, strained through a clean cloth, and thoroughly stirred with the milk. Heat is applied, and the whole contents of the vat raised to 84° or 86° for ripening, which should occupy from 30 to 60 minutes after the whole of the milk has been collected in the vat.

Testing Acidity.—The most reliable test at present is that founded on the rennet coagulation principle, and with great care in measuring and in thermometer readings, fairly reliable results are obtained. Useful information as to time of renneting can also be obtained by consideration of the previous treatment of the milk, such as the rate of cooling, the temperature in the morning,

the quantity of starter added, and the time of ripening. No standard for acidity at time of renneting can be given. This must be determined by each maker according to previous experience in his own particular case. The rennet test is useful only for comparing the acidity of the milk with that earlier or later, or in some other body of milk, such as the milk of the previous day.

Colouring.—When colouring is to be used, it should be added as soon as the whole quantity of milk is together in the vat. About 1½ ounce of annatto to 100 gallons of milk gives a medium bright colour. From 1 to 2 ounces per 100 gallons are commonly used, according to brightness of colour desired. The colouring should be diluted in not less than five times its bulk of pure water, to facilitate its thorough incorporation with the milk. The practice of using artificial colouring is being very properly discouraged.

Renneting.—Pure rennet of known strength should be used, and that also should be well diluted with pure water to ensure its rapid and equal distribution throughout the milk. In spring months sufficient rennet should be used to thicken the curd ready for cutting in 30 minutes, and in the summer months in 45 minutes. When the rennet is added, stirring of the milk should not exceed 5 minutes, as the milk should be quite still when coagulation begins. The surface may, with advantage, be slowly agitated to prevent the cream from rising till coagulation has commenced. From 4 to 5 ounces of rennet extract per 100 gallons of milk is usually sufficient in the spring months, and about 4 ounces in the summer months.

Cutting the Curd.—The curd is ready for cutting when it splits clean before the finger when inserted at an angle of about 45°. Horizontal and perpendicular curd-knives (fig. 697) are used, and the cutting is done very gently to avoid undue loss of fat in the whey. The object of cutting is to facilitate escape of the whey and the cooking or firming of the curd. In some cases a curd-breaker such as is shown in fig. 698 is used.

Cooking.—The cooking of the curd implies the change from the bulky, soft, flocculent mass when cut, to the drier, firmer, and tougher condition observed before the whey is run off. The process is a gradual removal of whey from the curd particles, and is brought about by

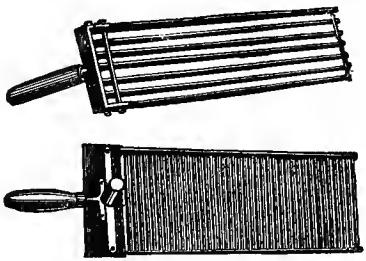


Fig. 697.—*Curd-knives*

the effects of heat and acid. Each of these agencies causes the curd to contract and whey to be pressed out. So that within limits the higher the temperature of scalding, or the greater the acidity, the firmer and more thoroughly cooked the curd. Cooking is facilitated by fine division of the curd in cutting.

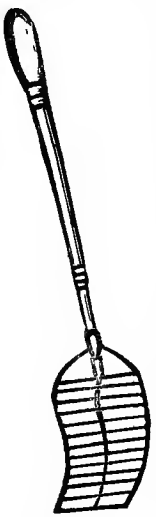


Fig. 698.—*Curd-breaker.*

After the curd has been reduced to small uniform cubes, heat is applied very slowly, and the temperature raised at the rate of 1° every four or five minutes. Rapid application of the heat at this time forms a skin on the pieces of curd, and thus prevents the proper expulsion of the whey from the curd that the heating is intended to accomplish. The heat in the modern vat is applied, as we have seen, by circulating hot water or steam between the two casings of the vat; and in the older circular tub by heating whey and pouring it over the curd. The temperature of scalding is that which has been found sufficient for the proper cooking of the curd, and will vary considerably in different dairies, and in the same dairies at different seasons. Curd which shows a tendency to drain freely will require

lower temperatures of scald than curd which is difficult to drain. The adoption of the proper temperature of cooking is an important factor in the making of uniform cheese. In early summer a lower temperature is employed than in late summer and autumn, otherwise the earlier cheese would be too hard. For summer and autumn common temperatures are from 98° to 102° Fahr. The temperature for cooking is reached in about one hour after cutting, gentle stirring of the curd being continued during the process of heating, and for 20 or 30 minutes after. The curd may then be allowed to settle until the necessary degree of firmness and acidity has been attained. It is most important in the making of a good keeping cheese that the curd is properly cooked and the acidity developed to exactly the proper extent before running off the whey.

Testing the Acidity.—A good test for acidity in the curd at this stage is the hot-iron test already referred to. A handful of curd is pressed in the hand until it is as dry and closely matted as possible, and applied to a hot iron just warm enough to melt it without charring. When applied lightly and removed very gradually, fine silky threads are observed to draw out between the curd and the iron. The length and fineness of these threads are reliable indications of the degree of acidity in the curd. When fine threads about a quarter of an inch in length are obtained, the whey, in general, may be removed at once, but the length of threads for the best results will vary considerably in different cases, and can only be arrived at from experience in a given dairy. With proper manipulation, the time from renneting to drawing off the whey will be from 3 to 3¼ hours.

Draining.—As soon as the whey is drained off, the curd is removed from the vat and placed on a cooler over racks covered with a cloth, through which the whey may readily escape. Unless the curd is very firm and dry, it should be stirred for a few minutes to prevent it matting at once, thus facilitating the escape of whey. The curd is then packed to a depth of 5 or 6 inches, and well covered to maintain the heat. In half an hour it is cut into pieces about 10 inches square and turned. It is subsequently turned and doubled up every half-hour until ready for milling.

Milling.—When the curd has developed so that fine threads from 1½ to 2 inches draw out on the curd when applied to the hot iron, it is put through the curd-mill (fig. 694). The curd at this stage of the process should have a smooth velvety feel, with a flavour like well-ripened cream. The length of time from placing the curd on the racks till milling varies from 1½ to 2 hours.

Salting.—After being milled or broken, the curd is stirred by hand for about 10 minutes to liberate accumulated gases and allow of aeration. It is then piled up and covered for another half hour to further mature before salting. Curd which is salted too soon does not ripen properly, but remains somewhat tough and open in texture and bitter in flavour. In salting, the curd is mixed with salt at the rate of about 2 lb. to 100 lb. of curd, the quantity varying with the time of year and the time to be allowed for ripening. After salting, the curd is left for 15 or 20 minutes to allow the salt to dissolve and to penetrate the curd before pressing.

Pressing.—Unless the curd is specially soft it should not be allowed to cool below 78° or 80° before packing into the chesset (figs. 699 and 700). Pressure is applied to the curd in the chesset very lightly at first, just sufficient to start the whey to run, and gradually increased to 30 cwt. by the end of three hours, so that the curd may become a completely solid mass. The curd is generally pressed in the chesset for three days, and turned and covered with a fresh dry cloth each day. To secure a smooth skin, the cheese is turned in the press on the evening of the day on which it is made, and next morning it is wholly immersed in water at 140° Fahr. for one minute. The bathing gives a tough thin rind to the cheese, and tends to prevent cracking. When sufficiently pressed, the cheese is well greased with pure lard, the ends protected with cotton cloth, and the sides well bandaged to maiutain the shape. When the surface is ex-

posed to the atmosphere it dries and tends to crack.

Curing.—The curing-room should be kept dry and well ventilated, and at a regular temperature of from 58° to 64°

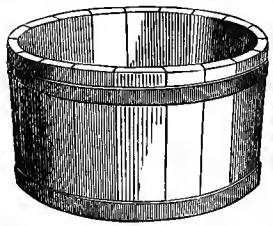


Fig. 699.—*Wooden chesset or cheese-mould.*

Fahr. A warmer temperature ripens the cheese quicker and a lower one slower. The cheeses are turned each day in the curing-room. A Cheddar cheese made and kept in this way should be ready

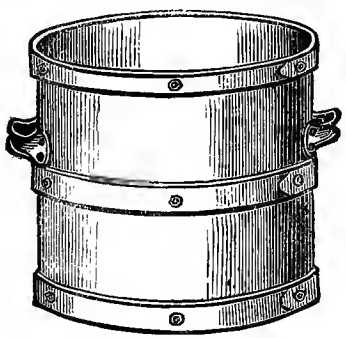


Fig. 700.—*Metal chesset or cheese-mould.*

for use in from two to three months, and should keep well for months afterwards if required.

SKIM-MILK CHEESE.

Skim-milk cheeses are made in several parts of the country, chiefly in Scotland, but without the addition of some portion of cream the cheese is dry and rather tasteless.

Attempts have been made in different countries abroad to replace the fat removed in the cream by the introduction of lard or other animal fat into the skim-milk. But the oleomargarine cheese thus produced is an inferior article, which has been very properly classed as a "dairy abomination."

STILTON CHEESE.

The making of cheese of one kind or another is an important industry in various parts of England. For the notes which follow upon the better known English cheeses the editor is indebted to Professor J. P. Sheldon. In appearance and character quite distinct from any other kind of British cheese, save the Yorkshire Cotherstone, which resembles it more in looks than anything else, Stilton cheese is at once one of the most modern and perhaps the most famous of all the many different kinds that are produced in the British Islands. Late in the eighteenth century it had a local reputation in the district around Melton-Mowbray, chiefly because the well-known Cooper Thornhill, who kept the Bell Inn at Stilton, on the Great North Road between London and Edinburgh, had it always at hand to regale travellers in the old coaching-days. It was first made by Mrs Paulet of Wymondham, a relative of Thornhill's, whose customers were sometimes "gratified" with it "at the expense of half-a-crown a pound,"—so we are told in Marshall's *Rural Economy*, which was published in 1790. It thus received the name of "Stilton cheese"; and the place where, as well as the method by which, it was made, were kept secret for some time. At length, however, the place and the method became known, and it was then made at various farms in the counties of Leicester and Rutland, while in modern days it has been produced in many parts of England, in the United States of America, in Canada, and elsewhere.

Characteristics of Stilton Cheese.—The distinguishing feature in the old-time Stilton method of cheese-making was the presence in the milk of a double quantity of cream—that is, the cream of the evening's milk was added to the morning's milk, which was then made into cheese. Hence, indeed, its superior quality, and the price it used to command. True Stilton cheese is still a double-cream cheese, wherever it may be made; but it is doubtful if more than a small proportion of the Stilton now made is a double-cream cheese. Modern science has modified the method so far as to produce fine Stilton from new milk

only, without the addition of cream. Well-made cheese, indeed, ought to be rich enough when yielded by good milk that is clean and fresh, without additional cream. And so, indeed, it is, except on the tongue of an epicure. But we must admit that Stilton is an epicurean cheese after all, and that the highest qualities of Stilton cheese have still extraneous cream in them.

Climate and Soil.—It is said that no other county can produce Stilton cheese equal to that of Leicester and Rutland, soil and herbage having so much to do with the result. It is probable, however, that this claim cannot be sustained, and that the finest qualities of Stilton can be produced elsewhere, on the same method, with a double quantity of cream, and from rich old pasture-land. It is also said that really fine Stiltons can only be made in the five months beginning with May and ending with September. This is probably correct, but the statement is equally applicable to other kinds of cheese.

Method of Making.—The Stilton method is as follows: The evening's milk is put into shallow "leads," or pans, and is skimmed next morning, the cream being mixed with the fresh milk of the morning. The rennet is added when the milk has been raised to a temperature of 83° Fahr., and coagulation is perfected in an hour afterwards. The coagulum is then broken a little and very gently, after which it remains at rest for a quarter of an hour: it is then put into the "leads," over which cloth strainers have been spread to receive it, and the whey drains slowly out of the curd. As the draining proceeds, the corners of the cloth are drawn together and tied, and this is repeated time after time until the curd has become fairly dry and firm. The curd is then put into a draining vat and broken up into pieces, during which time, exposed to the atmosphere and its germs, it becomes impregnated not only with the lactic acid ferment, but also with the spores of the mould, which is so marked a feature in all well-ripened Stilton cheese. A layer of curd is then put into the hoop, and on it a sprinkling of salt, care being taken not to let the salt get too near the outside; then another layer of curd, and on it salt as before, and so on until the hoop is full, when the mass of curd is lightly pressed down in the hoop.

The hoop is a cylinder of perforated tin, but without bottom or top, and it is placed on a shelf over which a cloth has been spread, and where the whey may still drain away. The hoop is turned "other end down" two or three times a-day, until the cheese is firm enough to be taken out of it, the time required being from five to ten days, or even longer, according to the temperature. The cheese is then bound tightly round with a cloth, which is repeatedly changed for a dry one, until the crust of the cheese has firmed, and the shape can be maintained without the aid of cloths. The cheese is then placed on a shelf in the cheese-room, where it ripens, and the blue mould so highly prized is developed—a process, as a rule, occupying a good many weeks.

No curd-mill is used in the Stilton method, and the cheese is not put into press. Grinding the curd, indeed, would liberate the cream, a portion of which would be lost in the draining, and pressure would cause more of it to escape. In a double-cream cheese the danger is obvious; and even in single-cream cheese there is always a loss of butter-fat through grinding and pressing. In the Stilton method the curd is a good deal exposed to the air. It oxidises it and admits of inoculation by the pollen of the well-known blue mould or fungus—by name, *Penicillium glaucum*—whose influence is predominant in developing the characteristic flavour, and to no small degree the mellow consistency, of the thoroughly matured Stilton cheese. Young persons aspiring to make Stilton cheese will woo success more favourably if they buy a thoroughly ripe, old, mellow Stilton cheese, break a portion of it up into pieces like raisins, and keep it on plates in the dairy. The rest of the cheese should also be in the dairy, helping to impregnate the air with the spores of the mould.

CHESHIRE CHEESE.

Made in the County Palatine of Chester, whose soil in some parts is presumably more or less influenced by saline deposits beneath, this grand type of British cheese was famous, not in Eng-

land only, but in various Continental countries, long enough before Stilton cheese had been heard of outside its native county of Leicester.

A West Indian planter, some generations ago, was boasting in a Cheshire dairy farmer's house of the fruits they grew in Jamaica, two crops in one year. The farmer went out, and came back bearing a huge Cheshire cheese. "This," said he, placing the cheese on the table, "is the fruit we grow here once, or even twice a-day!" Legend leaves it at that.

Cheshire cheese is no longer the only famous dairy "fruit" we grow in the British Islands to-day. Its reputation has not been lessened, save in a relative sense. Once it stood "first," and the rest were "quite out of it," if one may use a current expression. It still stands where it long ago did, not any longer as first, but on its own lofty pedestal. More famous still are the Stilton and Cheddar, though their fame is modern in comparison. It is still true that a fine old Cheshire cheese, a year and a half old, and mellow, and blue-moulded throughout, is simply unbeatable in its own special way as an epicurean treat.

The method of making Cheshire cheese is an embodiment of simplicity, which time elevated into a science in all the oldest dairies and not a few of the newer ones. Yet for all that, in many dairies given to experiment, various modifications have been introduced, not always with pleasing results. Some have aimed at making an early ripening cheese, the profit of which would not be so long in coming to hand. And the modification in that consists in using more rennet in the milk, and in developing lactic acid in the curd. This is done in some of the best establishments, but only to a safe and reasonable extent, by keeping the loose curd in its vat, in an oven for a day or a night, not pressing it beforehand. Where slow-ripening cheese is made, lactic acid is not intentionally developed in the curd.

It is not unreasonable to assume that the saline element which presumably impregnates the soil of large portions of the county has some direct influence in causing Cheshire cheese to ripen slowly, when lactic acid is not intentionally developed. And a slow-ripening is a long-keeping cheese, as a rule, whilst its blue-mould and its mellow consistency have not been hurried in their natural course of development.

Much less Cheshire cheese is being made nowadays than was the case a few score years ago, because the demands of the milk trade have been so imperative in recent times, and also because the importation into this country of huge supplies of cheese from Canada and the United States, since the beginning of the last decade of the nineteenth century, caused cheese-making to become much less remunerative in these islands than it was before. All this, fortunately for cheese-making dairymen, was collateral with the rapid expansion of the urban demand for country milk in the period denoted. And hence it is that much less cheese is made in Cheshire to-day than was the case a quarter of a century ago. Yet for all that, there is Cheshire cheese to be had, now, quite as excellent in all respects as that of fifty years ago.

LEICESTERSHIRE AND DERBYSHIRE CHEESE.

Between the types of cheese produced in these two adjoining counties there is a good deal of dissimilarity, alike in appearance and in character, though there is much in common between the methods under which they are produced. A first-rate specimen of either of them is, from a gastronomical point of view, a really excellent and attractive article of food. They are of open, flaky texture, and quite uncommonly mellow, whilst their flavour is remarkably pleasant and mild. At the same time, their quality is of the best, because the rich loams of the two counties produce milk which has long borne a high reputation. The marly soils of Leicestershire old turf land are admitted to have a marked influence on the flavour of the cheese made thereupon—a flavour which seems to be incapable of plenary imitation elsewhere. The method of making the cheese of either county is quite as simple as any other. The carboniferous limestone soils of northern Derbyshire produce cheese of good quality and pleasant flavour, from

milk which, coming from sound, dry land, is in brisk request for the milk trade amongst great centres of population, as in Lancashire and even in London.

LANCASHIRE CHEESE.

In the district known as "The Fylde," lying to the north of the Ribble, and bordering along the coast of the Irish Sea, a type of cheese is made—rich in quality and mellow in texture, like the land from whose herbage it is produced —which has a good deal of character all its own. To some extent, as in flavour and texture, it resembles the best of southern Derbyshire cheese, than which nothing simpler or nicer, or more appetising, can be found in any country. But the best of the Fylde cheese may be regarded as equal to the best of any other county, not of special manufacture, unless we except that of Cheshire and of Leicestershire. The finest qualities of it have been produced by the special employment of the lactic acid bacillus, developed in a few pounds of curd, not salted, which is held over to become slightly acid and mixed with the fresh curd of the following day. For the rest, the method of making it differs not at all, or differs very slightly, from the old-time method generally employed in the county of Derby. Local demand absorbs all of it, and therefore it is seldom seen away from its own county, within whose borders, indeed, it enjoys close relationship to a vast and excellent market.

YORKSHIRE CHEESE.

In times long gone by the North Riding of Yorkshire evolved two local specialities in the line of cheese—the "Cotherstone" and the "Wensleydale." The latter, made in any ordinary way of cheese-making that suggests itself to the dairymaid, and done up in different shapes and sizes, is the produce of small dairies in many instances, and is consequently without the uniformity of type which prevails in more extensive districts and larger prevalent herds of cows. The former has points of resemblance to the Stilton, alike in outward shape and internal appearance. Whether it is a copy of the Stilton or just a spontaneous and purely local evolution is perhaps conjectural. But in any case it is more like the Stilton than is any other type of cheese that has been evolved—so far as we know—in this or in any other dairying country. It is also popular, though not widely so in the sense that distinguishes the Stilton, and some of its admirers prefer it to Stilton.

OTHER WEST OF ENGLAND CHEESE.

The "blue veiny truckles" of Wilts have an ancient popularity, though the cheese has never attained a very large scale of manufacture. Not uncommonly called "loaves," they are usually about 9 inches deep, and of diameter corresponding thereto. The method of making is not different in any essential point from that employed in many other counties, and the cheese is of average merit.

"Single" and "double" Gloucesters —the difference being for the most part of thickness—are flat cheeses, like those of Derbyshire. They had at one time, long ago, a sort of cosmopolitan popularity. This is now mainly a matter of the past, and one can hardly see why it grew up, except on the ground that Gloucester is practically a seaport, though not on the sea, and that the local cheese, from small beginnings that could hardly be dignified by the name of business, gradually became an article of export to various countries whence came articles of import to the city of Gloucester.

ENGLISH SOFT CHEESES.

For good or for ill, English people have never taken kindly to soft cheese of any kind save to a very limited extent. Cream cheese we eat, at times, but more as a relish and a luxury than as a practical everyday article of diet. Cream cheese, indeed,—the easiest and simplest of all sorts in make,—is produced more or less in most dairying counties, though there is hardly anywhere a regular trade in it, save on a very slender scale. Any one with milk at command can make cream cheese: a

piece of muslin and a perforated box comprise the apparatus; in some cases the box is dispensed with. The process, indeed, consists in the cream automatically draining away its own superfluous moisture and becoming about as firm as fresh butter. This takes three or four days, during which time the cheesy little mass of cream becomes—at all events in warm weather—ripe enough for eating.

A genuine soft cheese of English origin is made in the smallest of English counties, at a place called Wissenden. It is named "Slipcote" cheese, because, when ripe, its skin becomes loose and seems to be slipping off. It is made of milk, just fresh milk, which is coagulated with rennet. The coagulum is put into a strainer to allow the whey to drain off. When dry enough, curd that will form a small cheese (of about 6 inches diameter and 2 inches thick) is put into the concavity of a plate, where it drains still more. When firm enough, the little cheese is placed between cabbage-leaves that are daily changed, and is ripe in a week or so.

BATH CHEESE.

In the days when Bath was one of the most fashionable resorts of pleasure, there was a cheese made in the vicinity and named after the town. The cheese, we are informed, was popular with visitors, who make a point of duty to patronise local specialities. It is no doubt true that the cheese had sufficient intrinsic merit as an article of food, quite apart from its claim as a local product.

This speciality in the domain of the dairy had its day, and passed, some fifteen to twenty years ago, into the limbo of things that are being rapidly forgotten. It is, however, now being revived in a form which, based on the science of dairying greatly improved in our time, may haply win back, it is to be hoped, all the ancient popularity of its prototype, with something added to it. Its modern exemplar is Mrs Mabel Loxton, of the Bath Creamery, and its location is promising.

The cheese is to all intents and purposes a "soft cheese," and ripens inside a week. In colour it is white, and in texture fairly firm; it cuts close and creamy in grain, and in taste it is piquant with the acid of the lactic acid bacillus. The cheese is small, varying in weight from one to two or three pounds, in accordance with the size of the moulds and the requirements of different customers. At present the demand for these soft cheeses is, we may hope, merely in its infancy.

CAERPHILLY CHEESE.

Caerphilly is by origin a Welsh cheese, but since about 1890 it has been making its way into different parts of the south-west of England—notably into the county of Somerset. It is a cheese that is much in demand amongst mining and other industrial communities in South Wales, and is gaining in popularity. Large quantities of the cheese now made in the counties of Somerset, Wilts, Dorset, and Devon are sent to Welsh towns at prices which range from 45s. to as high as 74s. per cwt. Each cheese weighs about 8 or 9 lb. It is lightly pressed, and is sold in a "green" state, usually when not more than ten to fourteen days old.

Method of Manufacture.—The method of the manufacture of Caerphilly cheese is thus described by Miss Jessie Stubbs, itinerant Instructress in cheese-making to the Somerset County Council:[1]—

"The method of making Caerphilly cheese varies with the length of time they are kept before being marketed. Sour or acid cheese take longer to mature, hence sweet cheese are more profitable, as they show quality at a much earlier date, and so do not shrink to the same extent as sour ones. In the summer months the milk is made up daily, but during the cold weather only once or twice each week, as all farmers did, and may do still, find great difficulty in obtaining the desired amount of acidity during the winter period unless the milk is very stale. The difficulty of obtaining acidity or sourness has been overcome in a number of Caerphilly dairies by the introduction of a 'pure starter,' so if the quantity of milk is large enough it may be made up every day with as

[1] *Jour. Brit. Dairy Farm. Assoc.*, 1908.

much ease as if it were the middle of summer.

"The evening's milk is strained into the cheese-tub and stirred occasionally to prevent the cream from rising; or if the day has been close and hot, it should be cooled to 70° Fahr. or under as soon as it is brought into the dairy. This prevents the milk from developing acidity during the night, and also makes the cheese more regular. Next morning starter is added at the rate of 1 quart per 100 gallons of milk, and the night's milk heated to 90° Fahr. It is then left for the acidity to develop, and the addition of the morning's milk. When all the milk is in, take a test with the acidimeter, and when the acidity is .01 higher than on the previous evening, put in the rennet. The amount of rennet varies on different farms, but, usually speaking, the quantity is 1 oz. to 50 gallons of milk. This will, if there is sufficient acidity present, thicken or coagulate the milk in three-quarters of an hour. The temperature for renneting depends on the time of year. As a rule, it should be from 86° to 90° Fahr. When firm, the curd is cut with American knives into pieces about the size of broad beans, and then gently stirred with the shovel breaker for twenty minutes, or until the curd is firm. The maker must use his or her own judgment at this stage, as the degree of firmness varies with the quality of the milk (the curd from rich milk requiring more firming than that from poor). After the right degree of firmness has been obtained the stirring ceases, and a test is taken to enable the maker to calculate the length of time before drawing off the whey. If the test shows the acidity to be .15 the curd is allowed to 'pitch' or settle for half an hour. It is then pushed back with the hands from the tap and the whey started off. If the curd is well pushed back from the tap the whey drains off, leaving the curd comparatively dry. This is now cut round the sides of the tub, piled in the centre, and allowed to drain for fifteen or twenty minutes. Then cut into oblong pieces, throw the curd from outside into the centre, again pile, and test for acidity. If the acidity is .2 to .25, leave for twenty minutes, and the curd is then ready to vat. No salt should be added. Take 9 to 11 lb. of curd for each cheese, according to the size of the vat, and carefully break it into the vat by hand without squeezing it, as unless care is taken over the breaking a loss of fat will occur. The cheese are now placed in the press, with about 4 cwt. pressure applied. Then take a test: the drainings from the press should be .3 to .35. In three-quarters of an hour the cheese are turned, and a little salt is rubbed on the outside to prevent the cloths from sticking. The cheese are then returned to the press, increasing the pressure to 6 cwt. Leave in the press until the following day. A brine strong enough to float an egg is prepared, and next morning the cheese are taken from the press and placed in the brine, with a small handful of salt on the top of each. At night they are turned, and the other side salted. The following day the cheese are taken from the brine and the moisture wiped off with a damp cloth, after which they are taken to the curing-room. There should be a certain amount of draught through the curing-room, as this will make the cheese coat faster, and they should be turned daily until ready to market. Some makers sell out weekly, keeping only about eight days' cheese in hand."

FOREIGN CHEESES SUITABLE FOR BRITAIN.

For the following notes regarding foreign varieties of cheese capable of manufacture in this country the editor is indebted to Professor James Long:—

The variety of cheese made upon the continent of Europe is much greater than can be realised by those who have not examined the subject. Those which are suitable, however, to British trade and taste are becoming numerous, although the importers confine themselves to Gruyère, Roquefort, Parmesan, Gorgonzola, Edam, and Gouda among the pressed, and to Camembert, Pommel, Port du Salut, and an occasional Brie among the soft varieties, most of which are included in the list, details of the manufacture of which are given below. France claims the longest

record, after which come Italy, Switzerland, and Germany. In Germany there is no specially fine variety, such as is usually recognised as a leading cheese, as in the case of the Gruyère of France and Switzerland. Nor do we find any important cheeses in such well-known dairy countries as Sweden, Norway, or Denmark.

Gruyère.

This cheese, which is made chiefly in Switzerland, and in those departments in France bordering upon that country, is well known in England. It is of great size, weighing from 100 to 150 lb., and often being more than 2 feet in diameter and 6 inches in thickness. It is a cheese which, at its best, is mellow, melting on the tongue, homogeneous, a light yellow in colour, without cracks on the crust, with a number of small holes which should not exceed three-eighths of an inch in diameter. The interior of these holes is moist, and the walls glazed, and they usually contain a little brine. The flavour is at once rich and nutty, somewhat resembling the very best Cheddar.

Gruyères are made in three qualities, —fat, half-fat, and lean,—or from full milk, half skim-milk, and skim-milk respectively. Most of the cheeses are made at factories or *fruitières*, to which the milk is delivered by the small producers.

It is warmed to 93° Fahr., and the curd brought by means of rennet in from 25 to 35 minutes. It is then cut with a long wooden knife, and subsequently stirred until the pieces of curd are no larger than peas.

The operation takes place in a handsomely made vat, or kettle of copper, frequently 5 feet in diameter. This kettle hangs upon a crane, and is swung over a wood-fire in the floor. Sometimes it is fixed, and the fire, made in a movable grate upon wheels, is run on a pair of rails from kettle to kettle.

The curd is next heated up to 135° Fahr., the stirring continuing until it has reached a proper consistence, which can only be ascertained by experience. The whole is then allowed to settle, and the cheesemaker skilfully passes a cloth beneath the curd, which has settled at the bottom of the vessel, brings up the ends on the other side, attaches the four corners to a hook hanging from a pulley, and in a few moments the curd is swung over a table and dropped into a mould waiting to receive it.

This mould is open at the side, and can be tightened at will. When once within it, the curd is carefully wrapped up with cloths, and after standing for a short time it is put under a press for the removal of the whey.

It is salted the next day, the salting continuing from day to day for a considerable period, two men being required to move the cheeses, which are placed upon shelves in the ripening-room.

Here three temperatures are, if possible, introduced, at the lowest, middle, and top shelves. These temperatures vary between 52° and 60° Fahr. Poor, or skim-milk, is, however, set at a lower temperature. What art there is in making Gruyère is chiefly displayed in removing the curd from the vat at the right moment, and in efficient pressing, salting, and ripening.

The other cheeses made in Switzerland, but all of which are unknown in the ordinary markets of this country, are the Spalen, the Bellelay, the Battelmatt, the Vacherin, the poor man's cheese, and the Schabzieger, in which the sugar of milk plays an important part. This cheese resembles the Myseost of the Scandinavian countries, and is not likely to become an important article of commerce.

Dutch Cheeses.

The two important cheeses made in Holland, both of which are sold in the English markets in large quantities, although much less popular than was formerly the case, are known as round or *Edam*, and flat or *Gouda* Cheese. We have seen Dutch cheeses made in various parts of the province of North Holland, and have found that, although the systems of most makers differ, it is only in minute details—which, however, are sufficient to improve the flavour of the cheese.

Edam.—A round Dutch cheese weighs about 5 lb. The milk is sometimes partially skimmed, but the best makers remove no cream from it. The cows are milked in the meadows, and the milk—

placed in round wooden tubs, which are taken to the cows by boat along the dykes which divide each farm—is renneted before starting for the dairy, at from 85° to 90° Fahr.

The curd usually forms in from 15 to 30 minutes, in accordance with the custom on the farm, and it is slowly cut with a wire cutter during 10 minutes, when the whey commences to separate.

The colouring is added with the rennet, if it is used.

After manipulation with the hands, the whey is baled out with a ladle, and the curd gathered together and again worked. As no mill is used, it is broken in the tub, and more whey removed, after which it is gathered together in a round mould and pressed for a short time. This pressing continues until sufficient whey is removed, when the curd is placed in a mould which resembles an egg-cup with a lid, which gives it its circular form. In this it is placed under a unique lever press, which is common in Dutch dairies.

Next day some salt is placed upon the top, but the cheese is reversed from time to time, while always being salted on the top. This continues for from 8 to 10 days, when it is put into a vat of thick brine for from 12 to 24 hours, being subsequently washed and removed to the ripening-room, where it stands upon a shelf, as near as possible at 70° Fahr. The cheese is turned daily until it is fit to sell.

It is well rubbed with linseed-oil and coloured yellow or red, in accordance with the market to which it is destined, the surface being scraped smooth and fine.

This cheese is made to an enormous extent in the province of North Holland, the chief markets being Hoorn, Edam, and Purmurend, all of which are within a convenient distance of Amsterdam.

Gouda.—The *Gouda*, or flat Dutch cheese, when at its best closely resembles the fine flavour of English Cheddar. It is much larger and heavier than the Edam, and although flat, has rounded sides. It is generally possible to purchase cheese of prime quality in Amsterdam, although its very high price prevents any considerable sale in this country. The milk is set at 92° Fahr., sufficient rennet being added to bring the curd in 25 minutes. It is then cut either with a knife or a lyre-like implement common among Dutch cheese-makers.

As the whey exudes, it is removed from the tub, and the curd carefully and gradually broken up into fine pieces with the hands. It is subsequently pressed and squeezed in a large perforated basin-like mould, in which it is again pressed for the removal of the whey.

The cheese afterwards goes into the mould which gives it its shape, and in 24 hours is salted, salting continuing from day to day until it is fit for the brine-vat, where it sometimes happens that hot water is added to the curd after the withdrawal of the whey, in order to harden it. This is a rougher plan of heating up than the operation as performed in England.

The Dutch cheeses are undoubtedly a boon to our working classes, many of whom prefer them to inferior home-made cheese at similar prices.

Parmesan.

Parmesan cheese is manufactured in Italy, chiefly in Parma and Emilia. It is generally known as Grana, on account of the fine grain into which the curd is brought during manufacture. In size and shape it resembles Gruyère, but often weighs more than 150 lb.

Parmesan requires keeping for a considerable period, sometimes three years, until it is fit for the market, and for this reason the export trade is in few hands, the makers being obliged to sell to the dealers while the cheese is new, for they complete the process of ripening in the marvellous caves which are built beneath their premises.

The true Parmesan is full of minute holes, and when cut in halves emits a sticky sweet substance, which has caused the term "honeyed" to be applied to cheeses of the finest quality. The flesh of the cheese is a pale straw colour, but the crust is often almost black from its age and the colour which has been applied to it. Like the Gruyère, the Parmesan is made in factories, where the milk is carried by small farmers, as in Switzerland. In one of these establishments,

where we were enabled to learn the process, as many as eighty persons brought in their milk, varying from 4 to 60 litres apiece. Two men only were required to conduct the work.

The milk is put into a kettle of solid brass, and resembling in shape an inverted bell. This hangs from a crane over a fire in the floor. The milk is heated to 92° Fahr., when the cheese-maker takes a piece of solid rennet, the size of a walnut, which he places in a cloth, and dipping this into the milk, wrings it for some minutes, until its virtue has passed into the milk. The strong-smelling animal matter is then thrown away.

The curd is sometimes brought in fifteen minutes. It is then roughly cut, and subsequently broken up with two implements — one called the *rotilla*, a long staff with wire-work bound around its head, and the other a rod with a disc at the end. Stirring is continued until the grain is almost as fine as large shot; some cold water is then sprinkled over the surface, the kettle is swung over the fire a second time, and the milk heated to from 104° to 110° Fahr., stirring being continued the while.

When the Grana, which is continually tested, is fit, the whey is dipped out, and the curd, which has been pressed into the bottom of the kettle, is removed into a cloth by two men, and placed in a large vessel for half an hour, after which it is removed into the mould. Here it is wetted with whey two or three times, in order to keep it sufficiently flexible; but it is also pressed by lying between two boards, and having weights placed upon the top.

The cloths are removed from time to time, when the cheese is covered with buckram, which gives an imprint to the skin. The buckram is subsequently cut, and the cheese is salted and again pressed. This process continues every other day for a fortnight, when the cheese is cleaned and scraped and taken to the ripening room, where it is greased and turned from time to time at suitable temperatures until it is ripe. In the ordinary way, however, it is sold to the dealer while it is yet young and green, very few of the makers venturing to complete the ripening process.

Gorgonzola.

This blue-moulded cheese, which somewhat resembles Stilton, is made chiefly in Lombardy, in moulds which are 12 inches in diameter by 12 inches high.

The curd is chiefly prepared by owners or drivers of cattle, and sold to the merchants when it has become solid, and formed into a cheese to ripen. The practice is to add the rennet to the evening's milk while it is from 85° to 95° Fahr., so as to bring the curd in fifteen minutes. It is then cut and broken up and ladled into cloths, which are hung up to drain in a cool apartment until the following morning.

The milk of the morning is served in a similar manner, except that the cloth holding the curd is placed into a bucket or vat to drain for some ten to fifteen minutes. At the end of this time the curd of the evening, which is cold, and the warm curd of the morning are placed in the cheese-mould, care being taken that the top and bottom, as well as the sides, are composed of the warm curd. The middle of the cheese is built up of alternate layers of cold curd and warm, the maker plunging his fingers occasionally into the mass to amalgamate them.

When filled, the cloth which envelops the curd is folded over the surface, and the cheese is allowed to settle until it has sunk into the lower half of the mould— for it is divided into two pieces: the top portion is then removed and the lower one reversed, that the cheese may drain and present a better face.

At the end of twelve hours it is again turned, and the mould tightened. Next day the cloth is removed, and the cheese begins to take its form.

It is then removed into an apartment of 65° Fahr., where it remains for three or four days, at the end of which time the mould is removed altogether, and salting commences.

One-half of the cheese, and that always the top, is daily sprinkled and rubbed with salt, being reversed the following morning. This salting continues until, in the judgment of the maker, sufficient has been given; brining is then practised for a few days, and the cheese is next taken to the cave, which must be cool

and moist, and is preferable if a damp draught is passed through it.

By this time a red mould has commenced to grow over the surface, and the cheese now requires great care in management and frequent turning. In from four to five months it will be ripe for the market, and will be veined throughout the interior with green mould.

The following are analyses of Gorgonzolas, some of which, it may be mentioned, are made without any mould, for the higher Italian classes, many of whom prefer it, as the green fungus has been at times produced by artificial means, which are objectionable:—

German Analyses.

		Soxhlet.
Water	36.72	43.56
Fat	33.69	27.95
Casein	25.67	24.17
Salt	3.71	4.32

Professor Kinch's Analyses.

	White.	Blue.
Water	48.99	24.96
Fat	26.50	26.10
Casein	21.11	43.46
Salt	3.40	5.22
Sugar	..	.26

The analyses by Professor Kinch were of cheeses made under the direction of the writer, at the Royal Agricultural College, Cirencester—10 gallons of milk made from 14 to 15 lb. of cheese.

Roquefort.

This cheese, also somewhat popular in this country, is properly made in the Aveyron, in France, from the milk of the ewe, some half-million of these animals being kept in one district alone for the purpose; but its large sale has now induced makers to use the milk of the cow.

The Roquefort is a small, round, flat cheese, weighing about 5 lb., and, like Gorgonzola and Stilton, it is veined with blue mould. This, however, is obtained in a different way, as will be seen.

The evening's and morning's milks are mixed together, and brought to a temperature of about 90° Fahr.; the rennet, which is made from the stomach of the lamb, is added, and the curd brought in a short time.

It is then cut and broken down, and much of the whey removed. The curd is afterwards conveyed into the mould in three layers, between each of which a quantity of specially prepared mouldy bread crumbs are sprinkled, the bread being made from a mixture of wheat and barley flour.

After pressure, and when the cheese has attained a distinct form, it is removed to the drying-room for two or three days, when it is carried to the celebrated caves which have made the district so famous, and which are extremely humid, the temperature being about 46° Fahr. Here it is from time to time scraped, as mould grows upon it, salted, and ripened. Machines, however, are now used in some instances for brushing the rind instead of scraping it, and also for piercing the cheeses with needles, in order to encourage the growth of the fungus within.

Cantal.

The Cantal cheese, which is an extremely important one upon the Continent, and which is probably destined to make its appearance in this country, is chiefly made in the Auvergne, and varies in weight from 40 to 100 lb. It is of piquant flavour, has a solid consistence, and may be termed a hard cheese.

Cantal is made from milk at a temperature of 75° Fahr.; the curd is broken up in an hour, the whey removed, and the solid remnants gathered together in fifteen minutes, when they are kneaded and further drained. The curd is then put into a vessel pierced with holes, and again pressed with the hands, and indeed with the body, the maker frequently getting on to the top of the mould and pressing with his knees. The mass is then reversed, and left under heavy pressure for twelve hours, being kept warm the while. Each lot of curd manipulated in this manner is called a tome—a full-size cheese requiring from three to four tomes in its manufacture.

When the real cheese-mould is about to be filled, the masses of now solid curd tomes are broken up with the fingers into small pieces, the whole salted, and finally put into the moulds in cloths, and sent to the press. Here the cheese obtains its final form, and when suffi-

ciently solid to be removed from the mould, it is taken to the cave to ripen.

The Cantal is ripened in about two months, and when made of full rich milk is of very fine quality.

Camembert.

This is the most popular of the small cheeses of the Continent which are sent to this country. It is made upon one principle, under various forms, in the department of Calvados and in the neighbouring districts of Normandy.

In a general way the evening's milk is skimmed and added to that of the morning, and heated to from 80° to 85° Fahr., sometimes higher. There are makers, however, who make three batches daily from three several milkings, thus preventing the necessity for heating the milk.

The curd is brought by the use of rennet in from one and a half to four hours, according to the custom on the farm. While still warm it is ladled into cylindrical moulds, placed upon mats made of rush or reed, upon benches of cement or galvanised metal. Each mould is nearly filled with each batch of curd, and by the time the next curd is ready, the first will have sunk in the mould by reason of drainage, when it is filled again.

When the second curd is sufficiently low the mould is skilfully reversed, and kept upon the cheese until it is firm enough to handle; it is then salted upon one side, and left until the following day to be salted on the other.

After salting it rests upon shelves for a few days, when it is carried to the *séchoir*, or drying-room, an apartment through which currents of air are induced to travel in all directions. Here a white mould appears; and when the velvety pile is at its best the cheeses are conveyed to the cellar, which is usually dark, damp, and free from draught.

It is then turned daily until covered with a green mould. During the growth of this fungus the flesh of the cheese will have gradually changed its condition, and in from five to six weeks it will be fit for market.

Camembert and Brie Bacteria.

M. Georges Roger, Director of the Laboratory of La Ferté, France, has isolated bacteria, which he claims are responsible for the maturation of Brie and Camembert. He has studied the mode of cultivation of these types, is acquainted with both the technique of the cheese dairy and the scientific causes of the changes which occur, and has adopted a system with the object of securing the best results. He cultivates the pure organisms, employs absolutely pure milk and sterilised rennet, giving special attention to the question of the purity of the dairy. It has been noticed that in successful French cheese dairies certain moulds are practically in possession. In some cases the results are only second-rate, while in others, and these the best, they are practically always good. The walls of the apartment and its shelves and plant are sterilised by the aid of boiling-water. Lime-washing follows, and this is succeeded by the process of inoculation with the spores and cells of the mould and the bacteria.

Brie.

This cheese, which is the most popular in France, is chiefly made in the department of Marne, not far from Paris, and sent to the Paris markets, where it obtains high prices. It varies from an inch to an inch and a half in thickness, and from 9 to 12 inches in diameter. Its character very much resembles that of Camembert, although it is differently made.

The new milk set at 83° Fahr. is brought to a curd in from three to four hours, although details differ upon various farms. The mould is made in two parts, the top portion fitting into the bottom. This is placed upon a mat and a beech board, and the curd is laid within it in large, thin, unbroken slices until it is full. It remains to drain until the top portion of the mould can be removed; the cheese is then reversed by the aid of a clean mat and board, and in time becomes firm, when the mould is removed altogether.

It is then salted, as in the case of the Camembert, and finally taken, first to the drying-room, and subsequently to the cellar, an apartment which, as we found in the Brie district, was not only extremely dirty, but positively reeked with fungoid growth upon the walls and shelves.

The cheese is speedily covered with white mould, with specks of blue here and there; it then goes to the cellar, and is soon covered with blue mould, upon which patches of a vermilion mould commence to grow.

There is no more delicious cheese than the Brie, not even excepting the Camembert.

The Neufchatel.

This cheese, sometimes called the Bondon, is largely made in the department of Seine Inférieure. It is a small loaf-shaped cheese, about 3 inches high, and 1½ to 2 inches in diameter, and is properly made from new milk, although the majority of makers, many of whom we have visited, in this department use milk which has been partially skimmed. For such cheeses the makers obtain only a penny apiece in the Paris markets.

The majority of the makers are farmers of the smallest class, who have not sufficient milk to make large cheeses.

The milk is set directly it comes from the cow, and sufficient rennet is added to bring the curd in twenty-four hours. It is then ladled into a cloth, stretched by the four corners over a draining-tub, and left to drain for twelve hours; the partially solid curd is then removed to a press, in which it remains for some hours, until in the judgment of the maker it is fit for moulding, At this moment it is worked up with the hand, and each cheese is moulded separately in a small brass cylinder, and placed upon a straw-covered shelf to dry. Here it becomes covered with white mould, which subsequently changes to blue, the apartment being maintained at 60° Fahr., or a little less.

The cheeses are turned daily; and when a second lot of white fungus has covered the blue it is ready for the market, and will keep a long time.

This cheese is salted after it has been dried upon the shelves for a day.

It should be added that although the Neufchatel is sometimes sold in a white or fresh condition, yet if ripened it becomes veined with blue mould as in varieties like the Stilton and Wensleydale, and in this stage it is one of the choicest varieties in the French market.

The Bondon, which is made in a similar form to the Neufchatel, is an unripened cheese made of new milk, and it is often produced in London by East End purchasers of sour or stale milk.

Pont l'Evêque.

This cheese, which is fairly well known in English dairy schools, although it is not upon the market, is one of a tasty and admirable character. It is made in different qualities, but the true cheese, which was formerly known as the Augelot, is produced from whole-milk. We have seen the process of manufacture in the dairy of one of the best makers near the village of Pont l'Evêque. The milk is brought to a temperature of 100° Fahr., and, the rennet being added, it is mixed with the milk by stirring or by the hand of the maker, the curd being produced in about fifteen minutes. The curd is subsequently cut with a knife, when a shallow vessel is placed upon it in order to express the whey, the whole being covered with a clean cloth. At the end of about ten minutes the whey is removed by baling, while the comparatively dry curd is placed upon rush mats, where it continues to part with its whey. When the curd is ready it is placed in square wooden moulds, which are turned several times during the succeeding half-hour; it is then placed upon a second mat, where it is turned some half a dozen times during the day. On the following morning the young cheese is firm and is salted with the finest salt—which has been well dried in the oven,—one side being salted in the morning and the other during the evening following. The cheeses are then taken to the first ripening- or drying-room and placed on the shelves upon rye straw, the apartment being well ventilated, and here it remains for three days, being turned each day. When quite dry the Pont l'Evêques are carried to the "cave," or final ripening-room, which is not of necessity a basement. During the process of ripening in the "cave" the cheeses are turned every other day, care being taken to prevent the entrance of flies. The best class of Pont l'Evêque remain in the "cave" from a fortnight to three weeks, depending on their thickness, cheeses of the larger size requiring a still longer time before they are fit for the table.

The best class of Pont l'Evêque is made only in the autumn, whereas the summer cheeses are made from May until autumn commences. These cheeses are made of the mixed milk of the morning and the evening, a portion of the cream being removed. The chief features of the process of manufacture are the rapid separation of the whey by early breaking of the curd and the prevention of the development of mould upon the surface, so that the process of ripening depends entirely upon the work of bacteria within the cheese.

ASSOCIATED BUTTER AND CHEESE MAKING.

An important development of the dairy industry is the organising of establishments in which the milk produce of the cows on several different farms can be collected together for united manipulation. These establishments are of different kinds, with different yet similar aims and objects.

Creameries.—The original conception of the creamery was, as a rule, to receive only the cream from the farmer, for which he was paid either by measure or weight, or, as is more preferable, according to percentage of butter-fat, or actual butter yield: in the latter case each farmer's consignment requires to be tested or churned separately. The former is the more convenient to the creamery staff, but the latter is more satisfactory, as a rule, to the consigner. A third plan, which has certain points to commend it, is for the farmer to bring the whole-milk to the creamery twice a-day—just after it is milked—and get it at once separated by the centrifugal separator. In summer he will likely take back with him the fresh skim-milk, for in that season he can usually turn it to better account on his farm than could be done by the creamery; but during the months of October to March inclusive there is usually a capital demand for separated milk in the large cities, at fairly remunerative prices, ranging from 4d. to 5½d. per gallon. If there are means of properly cooling the milk at the farm, and care be taken to keep the milk of each milking separate, it is not usually necessary to convey the milk to the creamery twice daily excepting during the period of warm weather.

In the creamery the cream is made into butter in large quantities at a time, thus securing a product of uniform character and appearance, which is so important in the sale of butter. In some cases creameries also do a considerable trade in selling fresh cream for table use in towns, this latter, indeed, being the more profitable method of disposal.

Butter-blending House.—This is a sort of modified butter factory, in which butter is collected in small quantities from farmers, graded according to quality, and submitted to a certain amount of remaking. The object here is to rectify the home defects in the "working" of the butter, to grade, blend, and remake it, so that it may be presented in the market in large quantities of uniform character and attractive appearance. This system has been highly successful in France, especially in Normandy, and is being carried out at various centres in this country with results which seem to be fairly satisfactory. In Ireland a considerable trade of this description was developed, but the great spread of the co-operative creamery system has tended to circumscribe the operations of the blending factory.

Dairy Factory.—Then there is the dairy factory, which, known perhaps by different names, embraces all the branches of dairying (excepting, most likely, the keeping of cows)—buying in new milk from many farmers, selling some of it as fresh whole-milk, making cheese of various kinds, separating the cream from the milk by the centrifugal separator, making butter, selling fresh cream, selling the skim-milk back to the farmers or through towns and villages, and perhaps feeding part of it to calves and pigs.

These latter are generally establishments of considerable size, and, like the creameries and butter-blending houses, are conducted in some cases as distinct businesses, and in others in co-operation with the farmers who produce and supply the raw material.

Co-operative Milk Depot. — The formation of co-operative milk depots by proprietors and tenant farmers in milk-producing centres in Scotland is referred to on p. 485.

INDEX TO VOLUME II.

DIVISIONS III. AND IV.

PAGE

Aberdeenshire manure experiments . . 51
Acidity in cheese-making 504
Advantages claimed for ensilage . . 293
Aftermath 253, 254
Agricultural seasons, calendar and . . 62
" year 57
Agriculture, influence of electricity in . 404
" insects of importance to . . . 443
Air and germination 155
" hot-, drying of grain 202
Aitken, Dr, on manuring potatoes . 298
Albumen in milk 480
Alfalfa, seed of 76
Alsike clover 75, 243
American and Canadian silos . . . 290
" hay-collector 267
" reaping-machines 174
Ammonium-salts better than nitrate of soda 11
Analysis of—
Cabbage 394
Carrots 394
Hops 383
Pasture grass 394
Potatoes 394
Turnips 394
Ancient notions regarding beans . . 153
" reaping-machine 172
" threshing-machine 210
Animals in relation to farm life . . 424
Apex, forming the, of stack . . . 197
Aphides, general treatment for . . . 444
Appliances, reaping 169
Arc, modes of describing 218
Aromatic herbs 404
Artificial drying of grain 202
Ascomycetes, the 411
Ash constituents and the seasons . . 13
" " importance of . . . 8, 9
" quantity of, in an acre of wheat . 95
Ash of—
Barley-straw 103
Bean- and pea-straw 148
Oat-straw 103
Rye-straw 103
Spent hops 384
Wheat-straw 102

PAGE

Atmosphere, nitrogen of 6
Atmospheric nitrogen for turnips . . 342
" influence on cream 490
Atmospherical complications in summer . 61
Autumn anomalies 65
" crops 66
" cultivation 65
" dunging for potatoes . . . 301
" field-sports in 65
" manured beans, sowing . . . 150
" planting of potatoes 308
" rain in 65
" rewards of labour . . . 65
" sowing peas in 154
" " wheat in 117
" weather and field operations . 65
" wheat 128
" and winter ploughing for turnips . 329
" and winter weather . . . 13

Bacteria, Camembert and Brie . . . 520
" in plants 418
Badger, the 425
Bagging grain 228
" -machine 224
Band-knots, placing the . . . 186
Bands and binding grain 184
Bank-vole 428
Barley—
Classifying by the ear 96
" by the grain 96
After corn, experiments on . . 134
Charlock 135
Crop values 90
Effects of season on yield and quality 21
Experiments at Rothamsted . 19, 133
Experiments at Woburn . . 43
Finishing sowing 133
Germination of, and the weather . 132
Grains in a bushel of 97
Harrowing for 132
Hummellers 228
Judging 97
Limits of culture 97
Malting 97
Manures for 37, 134

Barley—
Manuring. See also Rothamsted 19, 133
Meal 97
Mineral manures, effect on . . . 20
Nitrogenous manures on . . 19, 37
Oats and, mixed 138
Phosphatic manures for . . . 38
Quantity of seed 132
Quick drying 187
Reaping 187
Riddle 225
After roots, experiments on quality of 134
Rothamsted experiments with . 19, 133
Season and effect upon yield . . 21
Small sheaves 187
Smut 416
Soil for 133
Sowing 131, 132
Summer culture of 135
Superphosphate for, experiments on . 134
Stack-heating 200
Stage for cutting 168
Straw 103
" ash of 103
" strength of 103
Tillage for 131
Top-dressing 136
Uses of 133
Utilisation of 97
Varieties of 133
Weather and manures on . . . 22
Yield and weight of 97
Yorkshire trials in manuring . . 135
Barn-brooms 227
" hay- 270
" hoe 226
" implements 225, 226
" owl, the 431
Barrel churns 496
Barrels for early potatoes 315
Barrow, sack- 229, 230
Baskets, barn 226
" corn 227
" potato hand- 306
" seed- 121
Bath cheese 514
Bean-riddle 226
Beans—
Ancient notions regarding . . . 153
Aphis 444
Beetle 445
Botanical character of . . . 153
Broadcast grown 152
Consumption of 147
Containing poison 147
Cropping 152
Cultivators and grubbers . . . 150
Field-bean 146
Hand-hoeing 152
No harbour to weeds 152
Harrowing drills 152
Harvesting 208
Horse-hoeing 152
Leguminous plants 146
Manures for 38, 40, 149
Manures for turnips and . . . 33
And nitrogenous manure . . . 149
And peas 146, 398
And peas mixed 153
And pea-straw, ash of . . . 148
Ploughing for 150
Quantity of seed for 149
Riddle 226
Rows on the flat 152
Rust in 415
Beans—
Sowing 148
" autumn-manured . . . 150
" spring-manured . . . 151
Spring tillage for 150
Stacking 209
Summer culture of 152
Thatching 209
Varieties of 149
Weevils 459
Wheat after 119
Yield and weight of 147
Beet carrion beetle 445
" fly 446
" sugar- 403
Beetles—
Bean 445
Beet carrion 445
Brassy-flea 458
Cabbage flea 448
Click 454
Colorado 461
Corn ground- 455
Devouring slugs and snails . . . 474
Flour 456
Ground 469
" destructive to strawberries . 467
Mangold 446
Pea 445
Raspberry 467
Rose 469
Turnip-fly or flea- 463
" mud- 462
Useful 469
Beetroot 398
Bell's reaping-machine 172
Construction 173
Cost of reaping 173
Slow progress of 174
Work done 173
Binder, self- 177
Binding 178
Cost of cutting with 181
Efficiency of the 177
Examples of cost of cutting . . 181
General construction 177
Hands required 181
"Hornsby" 177
Other makes 180
Progress of the 180
Raking 181
Saving in crop 181
" in labour 181
Size of sheaves 181
Speed in cutting round . . . 181
Working the 181
Binding grain 184
" method of 184
" position of the band . . . 185
Birds devouring slugs and snails . . 474
" protection against disbudding by 439
" in relation to the farm . . 431
" in spring storms . . . 59
Bisset's binder 180
Black grass, seed of 83
Blackbird, the 436
Blending, house for butter- . . . 522
Blunt's ensilage press 292
Bolls, flax-seed 389
Bondon or Neufchatel cheese . . . 521
Bordeaux mixture for spraying . . 409
"Bosses," stack "kilns" or . . . 265
" for stacking hay 271
" for ventilating stacks . . . 201
Botanical character of beans . . . 153

Bottles, milk 482, 485
Boxes, butter 501
Boxing system of preparing potato-sets . 308
Bracken clock or garden chafer . . . 455
Break-furrowing 332
Breast method of water-wheel . . . 220
Brie cheese 520
British resources for corn production . 90
Broadcast sowers 123
" " hand 124
" sowing, disadvantages of . 157
" " of turnips . . . 335
Brome, seed of rye and soft . . . 86
Brooms, barn 227
Bucket water-wheel 217
Construction of the 219
Dimensions of the 218
Buckwheat 376
" cutting 210
" drying 210
" reaping 209
" seed of 78
Building, process of stack- . . . 193
Bulb-eating slug 474
Bulbous plants 401
Bullfinch, the 439
Bunt of wheat 416
Buntings 438
Bush fruit 400
" catch cropping . . . 400
" cost of planting . . . 400
" diseases in black currants . 400
Butter, working of 499
Butter-worker 500
" and combined churn . 498
Centrifugal butter-drier . . 500
Fresh butter 501
Hand-working objectionable . 499
Object of 499
Packing into crocks 501
Salting butter 500
Scotch hands 501
Yield of 478
Butter-blending house 522
Butter-drier, centrifugal 500
Butter-fat 478
Buttercups, seeds of 77
" flat-beaked "seeds" of . . . 77
Butterflies, cabbage 446
Butter-making 493
Boxes for transit 501
And cheese-making associated . 522
Churns 496
Churning 498
Breaking water 499
Preparing the churn . . 498
Sleepy cream 499
Speed of the churn . . . 499
Straining the cream . . . 498
Time of 494, 499
Ventilation 499
Whole-milk 495
Colouring butter 501
Effect of food on the churning temperature 495
Influence of salt 494
Ripening cream 493, 494
Starter jelly 493
Sweet-cream butter 494
Temperature of cream for churning . 494
Use of a "starter" or pure culture . 493

Cabbages 371
Analysis of 394
Aphis 449
Cabbages—
Black-rot of 418
Butterflies 446
Early v. 371
Flea-beetle 448
Gall-weevil 463
Growing of 393
And Italian rye-grass 372
Late 371
Lifting 373
Manuring 372
Moth 447
Plants 372
Produce 372
Root fly 447
Root gall-weevil 448
Seed of 73
Sowing and planting 371
Storing 373
For spring use 371
For summer use 371
Utilising 372
" stalks 373
Caerphilly cheese 514
Cake-feeding on pastures 282
Calendar and agricultural seasons . 62
Calves, milk for 486
Camembert cheese 520
Canadian and American silos . . . 290
Cantal cheese 519
Carnivora 424
Carriage harrows 249
Carrion crow 432
Carrots 393, 398
Analysis of 394
Cleaning for 394
Fly 445
Growing and heating in pits . . 396
Leaves of 396
Liability to rot 395
Pests 396
Pits 396
Preparing seed 395
Produce 395
Pulling 396
And rye 395
Seed of 81
Soil for 394
Sowing 394
Storing 395
Thinning 395
Tillage and manuring 394
Time of storing 396
Tops as food for stock . . . 393
Varieties of 395
Wireworms 453
Cart—
Farm tip- 349
Frames 190
Harvest 190
Jack's farm 318
Loading a 192
Ropes 191
Roping a loaded 192
Carting "gaitins" 192
" hours of 192
Casein in milk 479
Cat, wild 425
Catch-cropping bush fruit 400
Caterpillars, surface 465
Catstail, seed of 84
Cattle, selling fat, in spring . . . 59
" " in summer . . . 63
Cauliflowers 398
Celery fly 449

Centrifugal butter-drier . . 500
" separator 491
Cereal crops with grass seeds . . 250
" " insects injurious to . 449
Cereals, sowing 115
" manures for 7, 34, 40
stacking 189
Chaff as a foot-warmer 103
Chaffinch, the 438
Chamomile, seed of 79
Charlock, destroying 135
" seed of 73
Cheddar cheese 506
Character and composition . . 506
Character of milk 507
Chessets or cheese-mould . . . 510
Colouring 508
Cooking the curd 508
Curd-breaker 508
Curd-knives 508
Curing 510
Cutting the curd 508
Draining 509
Milling 509
Pressing 509
Renneting 508
Salting 509
Scale of points 507
Testing acidity of curd . . . 509
" " of milk . . 507
Treatment of the milk . . . 507
Cheese-making 501
Acidity 504
" controlling the . . 505
" measuring the . . . 506
And butter-making associated . . 522
Apartments for 502
Bath cheese 520
Brie cheese 520
Caerphilly cheese 514
Camembert cheese 520
Cantal cheese 519
Cheddar cheese 506
Cheshire cheese 511
Culture-starters 505
Curd-mill 502
Derbyshire cheese 512
Dutch cheeses 516
Edam cheese 516
English soft cheeses 513
Foreign cheeses suitable for Britain . 515
Gloucester cheese 513
Gorgonzola cheese 518
Gouda cheese 517
Gruyère 516
Lancashire cheese 513
Leicestershire and Derbyshire cheese . 512
Neufchatel or Bondon cheese . . 521
Parmesan or Grana cheese . . . 517
Pont l'Evêque 521
Presses 503
Propagation of a culture starter . . 505
Rennet 503
" action of 503
Ripening 504
Roquefort cheese 519
Skim-milk cheese 510
"Starters" 504
Stilton cheese 510
Utensils 502
Vat 502
Yorkshire cheese, "Cotherstone" and "Wensleydale" 513
Cheshire cheese 511
Chesset for cheese 510
Chicory 404
" seed of 80
Chickweed, seed of 74
" family, kidney-shaped seeds of the . 73
Chough, the 434
Churning whole-milk 495
Churns 496
Barrel 496
Combined, and butter-worker . 498
Diaphragm 497
End-over-end 496
Factory 497
High-speed 497
Holstein 497
Important features of . . . 498
Plunge- 496
"Speedwell" crystal . . . 497
Streamlet 497
Swing 497
Railway milk, or can . . . 485
Types of 496
Classification of farm seeds . . . 72
" insects 443
Clay's grubber 330
Cleavers, seed of 81
" family, "seeds" of the . . 81
Click beetles 454
Clifton Park system of growing grass . 287
Climate, effect of, on pastures . . 280
" soils and, for clovers . . . 241
Clip-fork 274
Clod-crushers 385
Clotted cream, Devonshire . . 492
Clover. See also Grasses 230
Alsike 75, 243
Creeping trefoil 243
Culture in England 375
Cutting 255
Dodder 423
" seed of 89
Experiments with 49
Extra late variety 376
As a forage crop 375
Frost injuring, seeds 250
Grasses and 230
" for permanent pasture . 245, 285
Importance of 241
Impurities in 244
Late variety of crimson . . . 375
Meadow trefoil 243
Perennial red 74, 242
Rape, seed of 89
Seed 241
Sickness, contributing cause of . 471
Soils and climate for 241
Sowing crimson 375
Suckling, seed of 76
Tedders injuring, hay 260
Trefoil or yellow 76, 244
Trifolium incarnatum . . 243, 375
Turning, hay 261
Varieties of 241
White 75, 243
" variety 376
Yellow suckling, seed of . . . 76
Club-root, or "finger-and-toe" . . . 417
Cockchafer 455
"Cocking" hay 261
Cocksfoot, seed of 87
Coiling hay 262
"Coling" 189
Collectors, hay 265
Collier in beans (aphis) 444
Colorado beetle 461
Comfrey, prickly 376

Composites, "seeds" of 79
Composition of milk from different breeds of cows 478
" of oatmeal 100
" of seeds 156
Concrete silos 290
Condensed milk 484
Conical cooler 483
" pit for storing potatoes . . . 322
Coolers, milk 483
Cooley system of raising cream . . . 489
Co-operative milk depots . . . 485, 522
Corn—
Barley after, experiments on . . 134
Basket 227
Bunting, the 438
Carts 190, 191
Crops 89
Culture, general principles of . . 144
Dressing 224
Experiments at Woburn . . . 48
Fly, the ribbon-footed . . . 450
Forking, in the field 191
Ground-beetle 455
Growing 89
Mode of lifting sacks of . . . 228
Process of reaping 182
Production, British resources for . 90
And rice weevil 455
Sacks 229
Sawfly 453
Scoop 227
Screens 225
And seed drill 124
Shovels 227
Stacks 189
At the steading 210
Stool for stack 193
And straw from high manuring . . 7
Strikes 227
Threshing and winnowing . . . 222
Thrips 456
Tying sacks of 228
Varieties of 91
Corn-band for sheavee 184
Corncockle, seed of 74
"Cotherstone" cheese 513
Cottage gardening 59
Cows, carrot-tops for 393
" milk from different breeds of . . 478
" parsnip leaves as food for . . 397
Cradle-scythe 171
Crane-flies 449
Cream—
Airing 487
Atmospheric influence on . . . 490
Cooley system of raising . . . 489
Deep-setting of 489
Devonshire clotted 492
" scalding system . . 490
Disadvantages of shallow-pan system . 487
Effect of food on the churning temperature 495
"Gerber" tester 479
Jar 489
Lactocribe for testing 479
Preserving 492
Raising 486
" methods of . . . 487, 491
" principles of 486
Ripening 404, 493
Scalding 490
Selling 492
Separated 492
Separators, centrifugal . . . 491
Cream—
Skimmer 489
Sleepy 499
Straining 498
Swartz system of raising . . . 489
Temperature of, for churning . . 494
" of shallow pans . 487
Test-tubes 479
Testing percentage of 479
Creameries 522
Creamery strainer 489
Creasoting poles for hops 380
Crested dogstail, seed of 86
Crocks, packing butter into . . . 501
Crop pests 442
Bean aphis or collier 444
Bean and pea beetles 445
" weevils 459
Beet carrion beetle 445
" fly 446
Cabbage aphis 449
" butterflies 446
" flea beetle 448
" moth 447
" root fly 447
" " gall-weevil . . . 448
Carrot fly 445
" wireworms 453
Celery fly 449
Click beetles 454
Cockchafer 455
Colorado beetle 461
Corn ground-beetle 455
" and rice weevil 455
" sawfly 453
" thrips 456
Daddy-long-legs or crane-flies . . 449
Death's-head moth 462
Diamond back moth 464
Eelworms 470
The flea-beetles 463
Flour beetles 456
Frit fly 451
On fruit 467
Garden chafer or bracken clock . . 455
Gout-fly or the ribbon-footed corn-fly 450
Hessian fly 452
Hop aphis 456
" fever-fly 458
" flea or brassy-flea beetle . . 458
" frog-fly 457
" red-spider 458
Mangold-leaf maggot 446
Onion-fly 459
Paraffin emulsion for 444
Parsnip fly 449
Pea beetle 445
" midge 460
" moth 460
" thrips 461
" and bean weevils 459
Pigmy mangold beetle . . . 446
Spring-tails 466
Surface caterpillars 464
Turnip and cabbage gall-weevil . . 463
Turnip-fly or flea-beetle . . . 463
" moth 465
" mud-beetle 462
" sawfly 466
Wheat bulb-fly 451
" midge 452
Wireworms 453
Cropping beans 152
" excise restrictions on . . . 403
" rank wheat 129

Crops—
Accompanying grass seeds . . . 250
Autumn 66
Cereal 115
Conditions favourable to large . . 13
Corn 89
Disposal of forage, in summer . . 63
Electricity for production of . . 404
Experiments in manuring . . . 1
Forage 367
Hay 251
Insect farm pests. See Crop pests . 442
Mangel 362
Manures for different 40
Potato 295
Saving in, by binder 181
For silage 292
Sowing with spring 250
Subsidiary farm 392
Turnip 324
Weeding cereal 129
Cross-cultivation for turnips . . . 332
Cross-fertilisation of grain 104
After culture 108
Details of the process 106
First year usually unsatisfactory . 107
Garton's work on 108
Good weather essential for . . 107
Mr Knight's efforts 105
Organs of fructification . . . 105
Percentage of success 108
Period for crossing 107
Process of 105
Protecting the ears 108
Mr Raynbird's experiments . . 105
Mr P. Shirreff's experiments . . 105
Time of natural fecundation . . 107
" required to fix type . . . 107
Cross-fertilisation of potatoes . . . 311
" furrow, depth of 146
" harrowing 126
Crosshill's clod-crusher 386
Cross-ploughing land 144
" " harrowing before . . 144
" " system of . . . 145
Crows 432
Cruciferous plants, globular-seeded . . 73
Cuckoo, the 440
Cultivating land for turnips . . . 328
Cultivation, antiquity of oat . . . 100
Antiquity of wheat 95
Autumn 65
Of flax 384
General principles of corn . . . 144
Of hemp 402
Of hops 377
Of leeks 398
Limits of barley 97
" rye 101
Cultivators and grubbers 150
" Martin's 331
" spring-tined, for flax culture . . 386
Culture-starters 505
Curd-breaker 508
" knives 508
" mill 502
Currants—
Aphides 468
Disease in black 400
Gall-mite 468
Magpie moth 468
Sawfly 468
Cushat, the, or wood-pigeon . . . 434
Cutting stage for grain harvest . . . 167
Cylindrical milk-coolers 483
Daddy-long-legs or crane-flies . . . 449
Dairy, the 475
Butter-making 493
Cheese-making 501
Churning 495
Compartments in 476
Consumption and selling of whole-milk 485
Cooling of milk 483
Cream-raising 486
Dampness to be avoided . . . 476
Destination of the milk . . . 484
Factory 522
Finishings of the 476
Herd recorder 480
Importance of temperature . . 477
Medley in the milk-room . . . 476
Milk 478
Milk records 480
" shelves 476
Pasteurisation of milk . . . 481
Power for the 477
Purifying and preserving milk . . 481
Separate 476
Separator 491
Shelves for 489
Situation of 475
Sterilisation of milk 482
Temperature of 477
Thermometers 477
Utensils 477
" cleaning 486
Verandah 476
Dairying and market gardening . . 397
" in summer 63
Daisy, seed of ox-eye 79
Dandelion, seed of 80
Death's-head moth 462
De Laune's seed mixtures 246
De Laval separator 483
Deep setting of cream 489
Derbyshire cheese 512
Devonshire system of scalding cream . 490
Dew, beneficial influence of . . 62
Diaphragm churns 497
Dibbling 159
" machines 163
Digger, potato- 317
Diseases, fungus, of plants . . . 405
" potato 296, 316
Ditches in pastures 284
Dock family, "seeds" of the . . . 78
Dodder, a parasitic flowering-plant . 423
Drainage of pastures 281
" waters, loss of nitrates in . . 15
" " soil and, at Rothamsted . 3
Draining, best season for 66
Dray's Hussey reaping-machine . . 174
Dressing stacks 276
" threshing and, machine . . 211
Drill cultivator 352
" horse-hoe 352
" plough, potato-digging by . 320
" " Scottish 302
" " triple 306
" " for turnips 334
" roller 307
" sowers 124
" " turnip 337
" sowing, advantages of . . 159
" " introduction of . . 334
" width of, for wheat 124
Drills, harrowing for beans . . . 152
Drums, safety-, for threshing-machines . 215
Drying, artificial, of grain 202
Dung for mangels 465

Dung, mechanical influence of . . . 5
" nitrogen in 5
" plant-food in 4
" for potatoes 297, 299
Dunging and sowing turnips in drills . 336
Dutch obseses 516
Duties of the farmer in summer . . 64

Edam cheese 516
Eelworms 470
Electricity in agriculture 404
Elevating apparatus for hoisting hay . 274
Elevator, hay 275
" of reaper-binder 178
" straw and hay 215
Embryo in seed germination . . . 156
End-over-end churns 496
Enoch's refrigerator 484
Ensilage. See also Silos 289
Advantages claimed for . . . 293
Analyses of sweet and sour silage . 291
Crops for 272
Experiments 50
Feeding value of silage . . . 293
Hay *v.* silage 293
History of 289
Introduction into Great Britain . 289
Losing in favour 295
Making sweet silage 291
Methods of pressure 290
Presses 292
Pressure for stacks 291
Silos 290
Stack 290
Sweet and sour silage 291
Entomology, literature of 471
Ergot 89, 414
Evaporation in spring 59
Ewes, attention to, in winter . . . 67
Excise restrictions on cropping . . . 403
Experiments in Aberdeenshire . . . 51
" on cross-fertilisation of grain . 105
" Rothamsted barley 133
" with manure at Rothamsted . 1
" in manuring hops 380
" in manuring turnips 350
" in manuring turnips at Carbeth . 342
" with manures by H. & A. S. . . 33
" with manures, &c., by R. A. S. E. . 42
" other, by agricultural colleges, &c. . 56
" with potatoes 298, 299
" in tedding 260

Factory churns 497
" dairy 522
"Fairy rings" in pastures . . . 287
Fallow wheat 117
Fanners 222
Farm, birds in relation to the . . . 431
" cart, Jack's 318
" crops, insect pests 442
" crops, subsidiary 392
" field operations on the . . . 57
" mammals in relation to the . 424
" plants, new varieties of . . . 116
" the seasons, weather and work . 57
" seeds. See Seeds 70
" tip-cart 349
" waggon 191
" work, subdivision of 60
" " summary of summer . . 62
Farmer's duties in summer . . . 64
" garden 59
" holiday 64
Farming, woad 403
Farmyard manure experiments . . . 50
" " for turnips . . . 346
" " for wheat at Rothamsted 4
Fat cattle, selling, in spring . . . 59
" " in summer . . . 63
Fat-globules in milk 479
Fat sheep, selling, in summer . . . 63
Feeding experiments 50
" hay for 254
" value of silage 293
Feerings, ploughing ridges and . . . 146
Fences, repairing, in summer . . . 63
Fertilisation, cross-, of grain . . . 104
" potatoes 311
Fescue grass, seeds of 85, 86
Field-bean 146
" madder, seed of 81
" -mouse 427
" operations, autumn weather and . 65
" " and spring weather . 57
" peas 147
" pits for potatoes 321
" slug 473
" sports in autumn 65
" stacks 202
" -vole 428
" -work to be well advanced . 60
" work in winter 66
Filter, milk 488
Finches, the 438
Finger-and-toe 417
" experiments with, in turnips . 49, 54
Flail for threshing rye-grass . . . 278
Flat milk cooler 483
Flax 384
Bolls containing seed 389
Clod-crushers 385
Culture 384
Dodder 423
Drying 390
Former uses 391
Grass seeds with 387
Growing 390
" and saving seed . . . 390
Harvesting, another method of . 389
Lifting 390
Manuring 387
Method of pulling 388
Norwegian harrow 386
Outlet for straw 391
Pond water 390
Pulling, steeping, and drying . 388
Recent trials 391
Retting, other methods of . . . 392
Rippling 388
Rotation for 385
Scutching 390
Seed 387
Seed, old 390
Seed, uses of 391
Selecting seed for sowing . . 390
Soil for 385
Sowing 387
Spring-tined cultivator . . . 386
Steeping or retting 389
Straw for paper-making . . . 391
" uses of 391
Tillage for 385
Weeding 388
Yield of 390
Flemish scythe 170
Flies, useful 469
Flour beetles 456
" rye- 102
" wheat for 93

Flowering season for wheat . . . 130
Flowers, farm culture of 401
Flues for stacking hay 271
Fly-catcher, the spotted 437
Foggage for grazing 284
Food and temperature for churning . . 495
" oats as, for stock 100
Forage crops 367
" " crimson clover as . . . 375
" " disposal of 63
" " importance of . . . 368
" plants, other 376
Foreign cheeses suitable for Britain . . 515
Forget-me-not, seed of 82
Forker, second 194
Forking corn in the field 191
" hay by hand in stack-building . 271
Forks, harvest 191
Fox, the 424
Frames for farm cart 190
Fresh butter 501
Frit-fly 451
Frost, beneficial influence of . . . 68
" cold and 68
" injuring clover seeds . . . 250
" plants uprooted by 68
" throwing out plants 118
Fructification, organs of 105
Fruit, bush 400
Fruit-trees, winter washing of . . . 457
Fruits 77
" insect pests injurious to . . . 467
" multiple 82
Fungoid attacks on hops 381
Fungus diseases of plants 405
Furrow, water- 137
Furze, gorse or whin 376
"Fylde" cheese 513

"Gaiting" 187
"Gaitins," carting 192
Game-birds 441
Garden, the farmer's 59
" slug 473
" snail 472
Gardening, cottage 59
" market 397
Garton's work as hybridisers . . . 108
Gauge, sheaf- 170
Geranium, seed of Dove's-foot and cut . 75
"Gerber" tester 479
Germination of barley and the weather . 132
Germination of seeds 154
Advantages of drill sowing . . . 159
Air and germination 155
Changes incidental to 156
Composition of seeds 156
Conditions essential for . . . 155
Deep and shallow sowing . . . 164
Destruction of seed 166
Dibbling 159
Dibbling-machines 163
Different methods of sowing and . 157
Disadvantages of broadcast sowing . 157
The embryo 156
Importance of economising seed . . 161
Methods of sowing compared . . 162
Moisture and 155
Multiple stems or "tillering" . . 157
Produce from methods of sowing . 161
Quantity of seed per acre . . . 161
Seed dissected 157
Thick and thin sowing 161
Tillering 161, 165
Transplanting 166
Germination of seeds—
Waste of seed 159
The young plant 156
Gilbert, Sir Henry, on dung for potatoes . 300
Gloucester cheese 513
Goldfinch, the 439
Gooseberries 400
Aphides 468
Magpie moth 468
Mildew 412
Sawfly 468
Gorgonzola cheese 518
Gorse 376
Gouda cheese 517
Gout-fly, or the ribbon-footed corn-fly 450
Grain—
Artificial drying of 202
Bagging 228
Crop values 90
Cross-fertilisation of 104
Degeneracy of 104
Garton's work as hybridisers . . 108
Imperial bushel measure for . . 227
Marketing, in winter 67
Mendel's laws and the improvement of 110
Threshing in winter 67
Grain-drying rack, the M'Ainsh-Robertson 208
" " the Richmond . . 202
" shed 207
Grain harvest 167
Artificial drying 202
Bands and binding 184
Beginning of 167
Cost of cutting with reaper and binder 181
Cutting barley 168
" thatch 200
Degrees of ripeness 169
Grain-drying racks 208
" shed 207
Judging ripeness 168
Labour 169
Loss by too early cutting . . . 167
Manual and self-delivery machines . 176
Process of reaping 182
" of stacking 189
" of thatching 195
Raking 185
Reaping appliances 169
Reaping barley 187
" oats 182
" wheat 188
Richmond grain-drying rack . . 202
Ripening process 168
" in the sheaf 167
Self-binder. See Binder . . . 177
Shedding or "shaking" . . . 168
Size of sheaves 185
Stack-heating 200
" ventilators 201
Stacking cereals 189
Stage for cutting 167
Stooking or shocking 185
Graip, potato- 315
Grana or Parmesan cheese 517
Granaries, preserving wheat in . . . 94
Grasses and clovers. See also Clover . 230
Clifton Park system of growing . . 287
Cutting early and late . . . 255
For different soils 245
Early grazing from permanent . . 287
Hay crop from permanent . . . 287
" experiments. See Rothamsted . 23
Ill-suited mixtures 255
Injury to young 192
Mildew of 412

Grasses and clovers—
Parks, letting in spring . . . 59
For permanent pastures . 245, 285
Seeds, depth for 247
" identification of . . . 82
" with flax 387
" rolling for 249
" for rotation 244
" sowing 247
" " with another crop . 286
" " without another crop . 286
Wheat after 119, 127
Varieties of 230
Varieties of, sown 244
Crested dogstall 233
Evergreen meadow-grass . . 240
Fine-leaved sheep's fescue . . 236
Fiorin or creeping bent grass (plant) 231
Floating sweet grass . . . 237
Hard fescue 236
Italian rye-grass 238
Meadow fescue 85, 234
" foxtail . . . 83, 231
Perennial rye-grass . . . 237
Red fescue 236
Rough cocksfoot 233
Rough-stalked meadow-grass . 240
Smooth-stalked meadow-grass . 239
Sweet-scented vernal . . . 231
Tall fescue 235
Tall oat-grass 84, 233
Timothy grass or meadow catstail 239
Various-leaved fescue . . . 235
Water meadow-grass . . . 241
Yellow oat-grass 232
Grazing, early, from permanent grass . 287
Greenfinch, the 439
Green-fly 457
Green-manuring experiments at Woburn . 47
Greens, cauliflowers, &c., farm culture of 398
Grubber, Clay's 330
" the Tennant 330
Grubbers and cultivators 150
Grubbing, advantages of 117
" for turnips 330-332
" for wheat 117
Gruyère cheese 516
Gulls 441

Hainault scythe 170
Hair-grass, seeds of 88, 89
Half-ploughing 332
Hall's refrigerating machine . . . 484
Hand-hoeing beans 152
Hand-hoes 353
Hand threshing-machine 216
Hares and rabbits 429
Harrison M'Gregor's self-delivery reaper . 176
" " mower . . . 257
Harrowing—
For barley 132
Before cross-ploughing . . . 144
Cross- 126
Drills for beans 152
Efficient 126
Oats before sowing 136
" after sowing 137
Potatoes 320, 321
Process of 125
Turnip land 330
Wheat 118
After wheat 125
The wheat-braird 250

Harrows—
Carriage for 249
Chain 249
Grass-seed 248
Iron 125
Norwegian, for flax culture . 386
Working wide 249
Harvest. See also Grain harvest . . 167
Cart 190
Forks 191
Mouse 428
Weather and 65
Work, magnitude of 65
Harvester. See Binder 177
" the stripper- 182
Harvesting beans, peas, and tares . . 208
" flax 388, 389
" grain 167
" hops 381
" by motor 182
Haulm or bean- and pea-straw . . . 148
Hawk, sparrow- 431
Hay—
Aftermath 253, 254
American, collector 267
Barns 270
Best stage for cutting . . . 254
Bosses or flues 271
Building field-stacks 268
Clover, sainfoin, and lucerne, cutting 255
"Cocking" 261
Coiling 262, 263, 264
Collecting 260
Collector 265
Crop 251
Crop from permanent grasses . . 287
Cutting early and late grasses . . 255
" rotation hay 255
" timothy 263
Early *v.* late stacking 269
Elevator 275
Experiments at Rothamsted . . 23
For feeding 254
Force in building stacks . . . 271
Form of stackhead 272
Foundations for stacks . . . 270
Ground for stacks 268
Growing rye-grass seed . . . 278
Hand-rake 272
Heading stacks 272
Height of stacks 273
High-forking by hand . . . 271
Horse-forks 274
Ill-suited mixtures for . . . 255
Injured by wet 254
Large stacks 273
Manuring the crop 251
" meadow 251
" rotation 251
Methods of collecting 262
Other methods of hauling . . . 267
Premature cutting 254
" stacking 269
Preparing for stacking . . . 268
Process of building stacks . . . 271
" of turning 262
Propping stacks 273
Raking 264
Roping stacks 272
Rotation 261
Sainfoin 370
Salting and spicing 277
For seed 253
Shed 270
v. silage 293

Hay—
Situation of field-stacks . . . 265
Size of stacks 271
Sledge 265
Stack-lifters 273
Stacking 264
And straw elevator 215
" mixed in drying . . 269
Tedders injuring clover . . 260
Tillage for 251
Time for cutting 253
" for field-stacking . . . 264
Turning clover 261
Varieties of 251
Yield of 253
Haymaking—
All-round or side cutting . . . 257
Artificial hay-drying 278
Clearing swathe ends 258
Close cutting 256
Controlled by weather . . . 258
Cutting 253
" laid crops 257
Difficulties with heavy crops . . 258
Direction to cut 257
Dressing stacks 276
English methods of 259
Hay-fork 262
Hay-stacking appliances . . . 273
Head-ridges 258
Hot air *v.* Neilson system of drying . 278
Irish methods of 276
Laid patches 257
Loosening lumps 258
Machines 259
"Making" the hay 258
Meadow hay 259
Methods of cutting 256
Mower *v.* scythe 256
Mowing-machines 256
Object of 253
One-way cutting 258
Permanent hay-stacks 270
Preparing to cut 255
Presser for hand-power . . . 279
Pressing hay 279
Rick-cloths 277
Scottish methods of 261
Sharp knives 256
Speedy 260
By stages 269
Study the weather 254
In summer 63
Swathe-turning and tedding . . 259
Thunderstorms and 263
Variations in practice . . . 258
Weather and 253
Heading hay-stacks 272
Head-ridges, cutting for hay . . . 258
Heat, influence of 12
Heating, stack- 200
Hedgehog, the 429
Hedges, planting 66
Hellriegel's discoveries regarding nitrogen 47
Hemp culture 402
Herbs, aromatic 404
Herring gull 441
Hessian fly 452
Highland and Agricultural Society's manure experiments—
Cropping 33
Insoluble nitrogenous manures . . 36
Lessons from incomplete manure trials 39
Manures for the barley crop . 37
Highland and Agricultural Society's manure experiments—
Manures for the bean crop . . . 38
" for cereals 34
" for different crops . . 40
" for oats 38
" tried 33
" for turnips and beans . 33
Manuring turnips 37
Object of the experiments . . . 33
Organic matter 40
Other research work 41
Results with nitrogenous manures . 35
" phosphatic manures . 34
" potash manures . . 37
The stations 33
Highland and Agricultural Society's experiments with potatoes . . . 298
" milk records 480
Hoar-frost 69
" injury by 69
Hoe, harn 226
Hoeing drilled wheat 129
" hand-, beans 152
" " potatoes 307
" horse-, beans 152
" kohl-rabi 393
" singling and, turnips . . . 352
Holstein churn 497
Homogenised milk 483
Hooded crow 432
Hooding, for oats 187
" for wheat 188
Hook, sickle or 169
Hops—
Analysis of hops 383
Aphis 456
Cost of hop-cultivation . . . 384
" of hop-planting . . . 384
" of wiring 378
Creasoting poles 380
Culture 377
After culture 379
Dressing plants 378
Drying hops 382
Fever-fly 458
Flea or brassy-flea beetle . . . 458
Frog-fly 457
Harvesting hops 381
Insect and fungoid attacks . . . 381
Longevity of the hop 381
Male and female hops 377
Manuring 379
" experiments . . . 380
Picking 381
Planting hops 378
Pocketing 383
Poling 381
Preparing land 377
Price of picking 382
Produce of hops 384
Rearing plants 377
Red-spider 458
Soil for hops 377
Spent hops as manure 384
Stacking poles 383
Tying up the bines 381
Varieties of 377
"Hornsby" binder 177
Conveyor-roll 178
Cutting the crop 177
Delivery of sheaf 178
Elevator and platform rolls . . 178
Finger arrangement 177
The knotter 178

"Hornsby" binder—
Needle of 178
Speed of 180
At work 180
Horse-beans 147
" fork 274
" " advantages of the . . . 275
" " for small farmers . . . 276
" " types of 274
" " working in sheds . . . 275
" -hoe 124
" " drill 352
" hoeing beans 152
" -power in a stream 218
" " for threshing purposes . . 221
" rake 260
Horses in summer, work for . . . 63
" vetches for 368
House-mouse 427
Howard's haymaker 259
" mower 256
" self-delivery reaper 176
" straw-trusser 216
Hummellers 228
Husk and kernel of oats 99
" " of wheat 95
Hussey reaping-machine 174
Hybridisation, Garton's work on . . 108
" progress of 109
Hymenoptera, useful 469
Hyphomycetaceæ (fungi) 417

Identification of farm seeds . . . 70
Implements, barn 225
" used in winter 67
Impurities in clover and grasses . 71, 244
Insect pests. See Crop pests . . . 442
" pests injurious to fruit . . . 467
" and fungoid attacks on hops . . 381
" attacks in summer 63
" " on turnips 326
Insects, classification of 443
" important in agriculture . . . 443
" useful 469
Insectivora 429
Iron harrows 125
" scythes 171
Irrigation crop, Italian rye-grass an . 376
" winter 66
Italian rye-grass 376
Cabbages and 372
Irrigation crop 376
Produce 376
Seed 85, 376
Sowing for forage 376

Jackdaw, the 434
Jack's farm cart. 318
" potato digger 317
" reaper and mower 257
Jar, cream 489
Jay, the 434
Johnson's ensilage press 292
Judging barley 97
" cheese, scale of points . . . 507
" of dryness in stacks 189
" ripeness of grain 168
" wheat 93

Kale, consuming 374
" thousand-headed 374
" transplanting 374
Kernel and husk of oats 99
" and husk of wheat 95
Kestrel, the 431
Kidney vetch 376
" seed of 77
"Kilns," stack, or bosses 265
Knapweed, seed of 79
Knife-sharpener for reaper . . . 183
Knives for breaking cheese curd . . 508
Knight, Mr, on cross-fertilisation of grain . 105
Knotter of self-binder 78
Kohl-rabi—
Advantages of 392
Planting 393
Produce of 393
Soil for 393
Storing 393
Thinning and hoeing 393
Tillage and manuring 393
Time for sowing 393
Uncertain crop 393

Labour, force of, in reaping oats . . 183
" for grain harvest 169
" hours of, in summer 63
" rewards of 65
" saving in, with self-binder . . 181
Labourers for working reaper . . . 175
Lactocribe 479
Ladders 222
Ladybirds 469
Lambs, weaning, in summer . . . 63
Lancashire cheese 513
Land rollers 142, 143
" rolling 141
Lapwing, the 440
Lark, the 440
Laval cylindrical milk-cooler . . . 483
Lavender 402
Laverock, the 440
Lawrence flat cooler for milk . . . 483
Lazy-bed system of planting potatoes . 310
Leeks 398
" culture of 398
" manuring 398
Leguminous plants 146
" seeds 74
Leicestershire cheese 512
Lens, examination of seed by pocket- . 70
Lice, general treatment of plant- . . 444
Lifter, sack- 229
Light, comparative duration of, in seasons 62
" influence of 12
Linnet, the 439
Literature of entomology 471
Loading a cart with sacks 229
Lucerne 369
The crop for dry seasons . . 370
Cutting 255
Experiments with 49
Seed of 76

M'Ainsh-Robertson grain-drying rack . 208
M'Cormick's reaping-machine . . . 174
Machine-sowing of oats 137
Maggot, mangold-leaf 446
Magpie, the 434
Maize 376
Malting barley 97
Mammals in relation to farm life . . 424
Management of pastures 280
Mangels 362
Application of manure for . . . 365
Artificial manures for 365
Autumn tillage 363
Beetle 446
Carting roots 367
Climate for 363

Mangels—
Cover with dry straw . . 366
Crop 362
Cultivation for 363
Dependency on manure . . . 365
Drills and flat rows 363
Dung for 365
Experiments at Rothamsted . 28, 364
Experiments with (R. A. S. E.) . . 49
After hoeing 366
Ingredients absorbed by . . 364
" of manure for 364
Injuring plants 366
Maggot 446
Manures for 364
Manuring 364
Plagues 366
Preliminary cleaning 366
Pulling 366
Quantity of seed 364
Rothamsted trials in manuring . 28, 364
Salt for 364
Seed 82, 363
Soils for 363
Spring tillage 363
Storing 366
" in houses 367
" method of 367
Thinning and after cultivation . 366
Time of sowing 364
Transplanting 366
Useful dressings for 365
Varieties of 362
Yield of 366
Manual and self-delivery machines . 176
Manures—
For barley 134
For beans 149
Beans and nitrogenous . . 149
Carting in winter 67
For cereals 7
Experiments in Aberdeenshire with . 51
" by Highland and Agricultural Society . . 33
" at Rothamsted . . 28
" by Royal Agricultural Society of England . 42
For mangels 364
For pastures . . . 282, 283, 287
Rainfall and time of sowing . . 10
Spent hops as 384
Top-dressing, in summer . . . 63
Turnip-tops as 358
Manurial elements in rain-water, loss of . 16
Manuring—
Barley 133
" Yorkshire trials in . . . 135
Cabbages 372
For carrots 394
Flax 387
The hay crop 251
Hops 379
" experiments in 380
Kohl-rabi 393
Leeks 398
Meadows, English trials in . . 252
For oats 138
Of pastures 281
Potatoes 297
" College trials in . . . 301
" general observation on . 301
Residues of previous 13
Turnips 339
Vetches 369
Wheat 128
Market-gardening 397
Marketing grain in winter 67
Martin's cultivator 331
Martins, swallows and 437
Maunds or wechts 225
Mavis, the 436
" catstail, seed of . . 84, 239
Meadow fescue, seed of 85
" foxtail, seed of 83
" grasses, seeds of . . . 87
" manuring 251
Meadows, English trials in manuring 252
Meal, yield of 100
Measuring grain 227
" water-supply 217
Mendel's laws in the improvement of grain 110
Mericarps 80
Mice 427
Microscope, examination of seeds by the . 70
Mildews, the 411
Milfoil, seed of 79
Milk 478
Albumen 480
Appliances for weighing . . . 480
Bottles 482, 485
Butter-fat 478
For calves 486
Casein 479
Churning whole- 495
Cleaning dairy utensils . . . 486
Cold store 483
Composition of cow's 478
" of, from different breeds . . 478
Condensed 484
Consumption and selling of whole- 485
Coolers 483
Co-operative depots 485
Destination of 484
Fat-globules 479
Filter 488
Homogenised 483
Laval cylindrical cooler . . . 483
Lawrence flat cooler 483
Methods of distribution . . . 485
Pan, iron 488
Pasteurisation of 481
Pasteuriser tin can 481
Purifying and preserving . . . 481
Railway churn or can 485
Records 480
Refrigerating machines . . 484
Selling skim- 492
Selling trade 485
Separated 492
Shelves 476
Sieve 488
Statistics 480
Sterilisation of 482
Sugar 480
Testing percentage of cream . . 479
Turbine-driven pasteuriser . . 481
Vat 502
Weight and specific gravity . . 480
Zinc dishes unsuitable for . . 488
Mill-dam 218
Milling properties of oats 140
Mineral constituents, the fate of . . 17
" manures for barley 20
" theory at Rothamsted . . . 5
Missel-thrush, the 436
Mixtures, standard seed 246
Modern reaping-machines 174
Moisture and germination 155
Mole, the 429
Morgan's hay- and straw-press . . . 279

Mossy land, insoluble phosphates for . 35
Moths—
Cabbage 447
Death's-head 462
Diamond-back 464
Heart or dart 465
Magpie 468
Pea 460
Raspberry 467
Turnip 465
Motive power for threshing-machines . 216
Motor, harvesting by 182
" driven pasteurisers 482
Mowers, types of 256
Mowing-machines. See also Reaping-machines 256
Multiple fruits 82
Mustard 73, 375
Myxomycetes 417

Needle of self-binder 178
Neilson system of drying hay . . . 278
Nelson system of drying grain . . . 202
Neufchatel or Bondon cheese . . . 521
Newberry's dibbling-machine . . . 163
Newington's dibbling-machine . . . 164
Nipplewort, seed of 80
Nitrates in drainage-waters, loss of . 15
Nitrogen, artificial supply essential for wheat 7
" in dung 5
" for potatoes 298
" natural restoration of, to arable soils 16
" " supplies of ash and . . 8
" for turnips 341
" of the soil and atmosphere insufficient 6
Nitrogenous manure, beans and . . 149
" " for barley crop . 19, 37
" " experiments . . 35
Norwegian harrow 386
Nutlets 81

Oats 98
Antiquity of culture of . . . 100
Arranging the force for manual delivery reapers 184
Bad work in binding 184
And barley mixed 138
Classification by the ear . . . 98
" by the grain . . . 98
Crop values 90
Cutting 183
" "roads" 183
Effect of soil on milling property of . 141
As food for stock 100
Force of labour in reaping . . . 183
Grains in a bushel of 99
Harrowing after sowing . . . 137
" before sowing . . . 136
Influence of season on varieties of . 139
Kernel and husk of 99
Limits of culture of 101
Machine sowing 137
Manures for 38
Manuring for 138
Meal 99
" composition of 100
" yield of 100
Milling properties of 140
New and old varieties compared . 140
Number of seeds per acre . . . 137
Origin of 101
Ploughing for 137
Preparing to cut 182
Quantity of seed 137
Raking 184
Oats—
Reaping 182
Riddle 225
Seed of golden oat 88
" of tall oat grass . . . 84
Sharp knives for cutting . . . 182
Smut of 416
Sowing 136
" mixed varieties . . 138
Stack-heating 200
Straw 103
" ash of 103
" chaff as a foot-warmer . 103
Summer culture of 139
Thick and thin sowing . . . 138
Tulip root of, or segging . . . 471
Varieties of 136
Water-furrows after sowing . . 137
Welsh trials in manuring . . 138
Yield and weight 99
Oil-can 223
Onions 398
" fly 459
" mildew 411
Orchards 400
Organic manures unnecessary for cereals . 6
Otter, the 426
Overshot method of water-wheel . 220
Owl, barn 431
" the brown or tawny . . . 432
" long- and short-eared . . 432

Pansy, seed of field- 75
Paper-making, flax straw for . . . 391
Paraffin emulsion, how to make . . 444
Parasites in seeds 72
" seeds of 89
Parks, letting grass, in spring . . . 59
Parmesan or Grana cheese 517
Parsley, seed of 80
Parsnips 396, 398
" fly 449
" leaves as food for cows . . 397
" seed of 80
" storing 396
Partridge, the 441
Pasteurisation of milk 481
Pasteurisers, belt-driven . . . 482
" motor-driven 482
" turbine-driven 481
Pastures—
Application of manures . . . 283
Clifton Park system of growing grass . 287
On different soils 280
Drainage of 281
Drains and fences 284
Dressings of manures . . . 282
Effect of climate on 280
Elliot's, Mr, improved seed mixture for 288
"Fairy rings" in 287
Feeding cake on 282
Formation of permanent . . . 285
Grass, analysis of 394
Grasses and clovers for permanent 245, 285
Grazing after hay 284
Insufficient attention to . . . 280
Management of 280
Manures for permanent . . . 287
Manuring of 281
Permanent, on poor clay soil . . 288
Profit from 281
Should not be mown 280
Sowing grass with another crop . . 286
Sowing grass seeds alone . . . 286
Sowing permanent 286

Pastures—
Stocking of 283
Trials in England . . 49, 285, 286
Value of 284
Water-supply for 284
Weeds in 284
Peas—
And beans 146, 153, 398
Beetle 445
Consumption of 148
Harvesting 209
Midge 460
Mildew of 412
Moth 460
Produce of 148
Sowing 153, 154
Stacking 209
Straw 148
Summer culture of 154
Thatching 209
Thrips 461
Tillage for 153
Weevils 459
Peewit, the 440
Perennial red clover 74, 242
" rye-grass, seed of . . . 85, 237
Permanent pasture, formation of . 285
" grasses and clovers for . . 245
Pests. See Crop pests 442
Pheasant, the 441
Phoma fungus in swedes 414
Phosphates for turnips 343
Phosphatic manures, experiments . 34
Phosphoric acid for turnips . . 341
Phycomycetes, the 405
Pickling wheat 130
Pigeons 434
"Pirling" 186
Pits, carrot 396
" field, for potatoes 321
" turnip, in the field 361
Plant-food in dung 4
" insoluble phosphates as . . 53
Planting cabbages 371
" kohl-rabi 393
" potatoes 303
" strawberries 399
Plants, fungus diseases of 405
" frosts throwing out 118
" leguminous 146
" lice, general treatment for . . 444
" new varieties of farm . . . 116
" uprooted by frost 68
Plough—
Advantages of the double-furrow . 120
Digging 320
Double-furrow 120
Scottish drill- 302
Triple drill- 306
Ploughing for beans 150
" cross-, land 144
" or grubbing for turnips . . 329, 330
" lea in winter 66
" for oats 137
" ridges and feerings 146
" in spring 60
" for wheat 117
Plovers 440
Plunge-churns 496
Poas, seeds of 87
Poison, beans containing 147
Polecat, the 425
Pont l'Evêque cheese 521
Porcelain milk dish 488
Portable threshing-machine . . . 213
Portable weighing-machine . . . 230
Pot-culture experiments 50
Potash for potatoes 298
" for turnips 341, 343
" manures, experiments . . . 37
Potatoes 295
Adjusting force of labour . . . 320
Dr Aitken on manuring . . . 298
Analysis of 394
Application of manure for . . . 301
Arranging the gatherers . . . 317
Assorting 317
Autumn dunging 301
" planting unsuitable . . 308
Ayrshire practice in planting . . 306
Barrels for early 315
Blossom, vertical section . . . 312
Boxing system of preparing sets . . 308
Carting dung for 302
College trials in manuring . . . 301
Colorado beetle 461
Complete planting as it proceeds . 306
Conveying seed to the planters . . 305
Covering in 306
Cross-fertilisation 311
Culture after 307
Death's-head moth 462
Depth of sets and distance apart . 307
Difficult to preserve 321
Digger 317
Adjusting the 319
Collecting carts 318
Depth of digging 319
Harrows following 317
Preparing for the 317
Speed of 317
Digging by drill-ploughs 320
Disease 296, 316, 406
" resisting varieties . . . 310
Diseased tubers 318
Distributing dung from carts . . 303
Distribution of the 296
Drill roller 307
The drill system 304
Dung and seed not to be left uncovered 306
Dung for 297
Early blight or leaf curl . . . 417
Experiments in spraying . . . 49
Experiments with late planting . . 307
Filling dung 302
Forking after ploughs 321
Frosted 323
Gatherers required 317
General observations on manuring . 301
Good potatoes 296
Graip 315
Hand-basket 306
" hoeing 307
Harrowing 320, 321
Heating 323
Improved digger best 321
Ingredients in manure 298
Introduction into Europe . . . 295
Land suitable for planting . . . 296
Lazy-bed system 310
Lifting and selecting 314
Male and female organs 311
Form of manures for 298
Manuring for 297
Marking fertilised plum . . . 313
Mechanical influence of dung on . 297
Medium-sized 316
Methods of raising 315
Need for new varieties 315
Nitrogen for 298

Potatoes—
Period of development . . . 314
Pits 321
Planting 303
In autumn 308
On the flat 304
Machines 305
The seed 305
Boxed seed 309
Ploughs 320
Plum 313
Potash for 298
Too much potash injurious . . 298
Preserving sets 304
Process of cross-fertilisation . . 312
" digging 318
Quantity of seed per acre . . . 304
Quickly acting manures for . . 297
Raiser attached to plough . . . 321
Raising 315
Early varieties 315
By the graip 315
Late or main crop . . . 316
New varieties of 310
Retain only superior varieties . . 314
Ripe plums 313
Rothamsted experiments with . . 299
Scab 417
Section of a flower 311
Securing and storing seeds . . . 313
Seed 303, 311
" for autumn planting . . . 308
" magnified 313
" pits 323
Seedless varieties 311
Shaws as thatch 323
Single *v.* drill plough . . . 304
Small 316
Soil and tillage for 296
Sowing artificial manure . . . 303
" the seed 313
Speedy marketing 316
Spreading dung 303
Spring dunging 302
" tillage with autumn dung . 302
Storing 321
" seedling 314
" wet 323
Tillage for 296
Time to lift 315
" for planting 307
Tubers boxed 308
" free from earth . . . 318
Typical dressings 297
Varieties of 295
" in use 296
Ventilating pits 323
Warty disease of 410
Weather and digging 320
Wheat after 119
Width of drills 307
Winter rot of 412
Yorkshire method of storing . . 322
Young seedling 313
Power for the dairy 477
" motive, for threshing-machines . 216
Preserving cream 492
" milk 481
Presses, cheese 503
Pressing hay 279
Prey, birds of 431
Prickly comfrey 376
Prismatic boss for ventilating stacks . 201
" pit for storing potatoes . . . 322
Procrastination, evils of . . . 61
Pulverising ploughs 330
Pumpherston, experiments with manures at 33
Pure-culture for butter-making . . . 493
Purifying and preserving milk . . . 481

Rabbits, hares and 429
Racks for drying grain . . . 202, 208
Railway milk-churn or can . . . 486
Rain in autumn 65
" snow-water and 69
" in spring 59
" in summer 62
" in winter 68
Rainfall, influence of 11
" and time of sowing manure . 10
Rain-water, loss of manurial elements in . 16
Raising cream 486
" potatoes 315
Rake, hay land- 272
Raking grain 185
" hay 264
Rakings, drying 185
Ransomes' horse-rake 260
" threshing-machine 215
Rape 374
Rapes, seed of 73
Raspberries 400
Beetle 467
Moth 467
Weevil 467
Rats 426
Raven, the 432
Raynbird, Mr, on cross-fertilisation of grain 105
Reaper and mower, Jack's . . . 257
Reaper-binder. See Binder . . . 177
Cost of cutting with 181
Manual *v.* self-delivery . . 176
Side-delivery 176
Reaping—
Bands and binding 184
Barley 187
Buckwheat 209
Cost of 175
Oats 182
Process of 182
Raking 185
Size of sheaves 185
Stooking or shocking 185
Wheat 188
Reaping appliances—
Binder 177
Harvesting by motor 182
Scythe 170
Sickle or "hook" 169
Reaping-machine 172
The stripper harvester . . . 182
Reaping-machines—
American 174
Ancient 172
Bell's 172
Draught of 175
Dray's Hussey 174
First effective 172
Force required 175
Harrison M'Gregor's 176
Historical 172
Howard's 176
Knife-sharpener 183
M'Cormick's 174
Manual and self-delivery . . 176
Modern 174
Nineteenth-century machines . . 172
Perfect workmanship 175
Price of 175

Reaping-machines—
Speed of 175
Varieties of 175
Records, milk 480
Recreation, winter 67
Red-clover seed 401
Red-shank, seed of 78
Reed-bunting, the 438
Refrigerating machines 484
Rennet 503
Research work in Aberdeenshire . . . 51
" by Highland and Agricultural Society 33
" at Rothamsted 1
" by Royal Agricultural Society . . 42
Retting flax 389, 392
Rhubarb 399
Rib-grass, seed of 77
" seeds, the two-faced . . 77
Richmond grain-drying rack . . 202
" potato-planter 305
Rick-cloth for hay-stacks 277
"Rickling," advantages of . . . 189
" temporary stacking or . . 189
Riddles 225
Ridges, ploughing, and feerings . . . 146
Ring-dove, the 434
Ripening cream 493
" grain 168
Rippling flax 388
"Roads," cutting 183
Rodents 426
Rollers—
Diameter and weight of . . . 142
Divided 142
Drill 307
Water-ballast 143
Rolling for grass seeds 249
" wheat 118
Rolling land 141
Process of 143
Speed in 143
Time for 143
Rook, the 432
Root- or bulb-eating slug 474
Root-alcohol for industrial purposes . . 403
Roots. See Turnips, Mangels, &c.
Carting 366
Sowing in summer 63
Storing 366
Quality of barley after . . . 134
Rothamsted experiments . . 28
Ropes, care of 191
" cart- 191
" straw for 196
Roping hay-stacks 272
" a loaded cart 192
" lozenge 198
" stacks 198
Roquefort cheese 519
Rose, mildew of 412
Rotation for flax 385
" hay 261
" " cutting 255
" " manuring 251
" seeds for, grasses . . 244
" experiments at Woburn . . 46
Rothamsted experiments . . . 1-32
Barley 133
Continuous growth of . . . 19
Manuring permanent grass from 1856 22
Produce of grain and straw averages . 20
Produce of hay per acre—1856-1902 . 23
Grass for hay 23
Changes in herbage by . . 27
Complete manures . . . 26
Rothamsted experiments—
Grass for hay—
Effect of lime 27
Effect of manures upon herbage . . 24
Mineral manures alone . . . 26
Percentages of herbage—1856-1902 . 25
The unmanured plots 24
Use of nitrogenous manures alone . 24
Other experiments 32
Potatoes 209
Root crops 28
Average produce of roots . . . 28
Continuous growth of mangels . . 28
Effect of manures on tilth . . . 31
Farmyard manure for mangels . . 29
Manures and incidence of disease . 32
Nitrogenous manures for mangels . 30
Potash salts for mangels . . . 30
Produce of roots and leaves . . 29
Proportion of manure recovered in crop 31
Quantities of manures per acre . . 28
Trials on turnips 342
The soil 2
Soil and drainage-water investigations . 3
Wheat—
Ammonia with individual ash constituents 9
Ammonium-salts alone . . . 8
Ammonium-salts with ash constituents 6
Autumn and spring sowing of ammonium-salts 10
Behaviour of lime in soil . . 18
Continuous growth of 3
Effect of annual residue from ammonium-salts—average 1852-1906 . 14
Effect of annual residue of ash constituents—average 1852-1906 . . 14
Effect of autumn and spring applications of ammonium-salts . . . 9
Effect of autumn weather due to fallowing 15
Effects of residues of manures . . 13
The fate of mineral constituents . 17
Influence of season 12
Produce of wheat with ammonium-salts—average 1852-64 . . . 8
Produce of wheat with farmyard manure—1844-1901 4
Produce of wheat with nitrate of soda and ammonium-salts—average 1893-1902 4
Produce of wheat variously manured —1893-1902 9
Produce of wheat variously manured —average for fifty-five years . . 6
Produce of wheat without manure—1844-1901 4
Proportion of corn to straw . . 12
Tracing the fate of manures . . 14
With ash constituents . . . 5
With farmyard manure . . . 4
With nitrate of soda 10
Without manure 3
The yield of dressed grain, &c., 1873-1902 12
Rove beetles 469
Royal Agricultural Society's experiments—
Continuous growing of wheat and barley 43, 44
Ensilage experiments 50
Experiments with clover . . 49
" lucerne . . 49
" mangels . . 49

Royal Agricultural Society's experiments—
Experiments with potatoes . . . 49
Feeding experiments . . . 50
"Finger-and-toe" in turnips . . 49
Green-manuring experiments . . 47
Hellriegel's discoveries . . . 47
Objects of the Woburn experiments . 42
Other experiments with corn crops . 48
Pasture experiments 49
Pot-culture station 42, 50
The rotation experiments . . . 46
Woburn station 42
Runch, seed of 73
Rust, white 411
Rye 370
" carrots and 395
" limits of culture of . . . 101
" sowing 141
" straw 103
" yield and weight of . . . 101
Rye-flour 102
Rye-grass, cabbages and Italian . . 372
" flail for threshing . . . 278
" growing and handling, seed . 278
" growing, seed 278
" Italian 376
" seed of 84, 85
" yield of, seed 278

Sack-barrow 229, 230
" lifter 229
Sacks—
Corn- 229
Loading a cart with 229
Mode of lifting 228
Placing, in the field 120
Seed- 121
Tying, of corn . . . 228
Sainfoin 370
" cutting 255
" hay 370
Salting butter 500
" and spicing hay . . . 277
Sandringham dairy-herd recorder . . 480
Savoys 397
Scarifier, drill- 352
Scientific character of Rothamsted trials . 3
Scoop, corn- 227
Scorpion-grass, seed of 82
Scotch hands for butter-making . . 501
" threshing-machine 211
Screens, corn- 225
Scutching flax 390
Scythe 170
Common 171
Cradle- 171
Cutting "roads" with . . . 183
Hainault 170
Iron 171
Method of, reaping 172
Setting a 171
Sharpening 172
Speed with a 172
Straight sned 172
Unsuitable for reaping wheat . . 188
Seasons, the 57
Ash constituents and 13
Calendar and agricultural . . . 62
Effect of, upon barley 21
Influence of, on oats 139
" on crops 12
Seed—
Adulteration and deterioration . . 71
Of buttercups 77
Buy, in good time 115
Seed—
Change of 115
Of the chickweed family . . . 73
Classification of farm 72
Of the cleavers family . . . 81
Clover 74, 241
Colour and gloss 71
Of composites 79
Of the cruciferous plants . . 73
De Laune's mixtures 246
Depth for grass 247
Of the dock family 78
Drill, hand 124
" turnip 337
Examination of 70
Form and surface of 70
Frost injuring clover . . . 250
Germination of 154
Grass 82
Hay for 253
Identification of 70
Improvement in 115
Impurities in farm 71, 75
Leguminous 74
Mericarps 80
Multiple fruits 82
Nature of farm 70
New or old 117
New varieties of farm plants . . 116
Of parasites 89
Parasites in 72
Quantity of seed per acre . . . 161
Quantity of, for barley . . . 132
" for oats 137
" for wheat . . . 118
Two-faced rib-grass 77
For permanent pastures . . 245, 285
Red-clover 401
For rotation grasses . . . 244
Sacks for 121
Size of 70
Sowing grass 247
Standard mixtures of 246
Testing 116
Time 115
" seasonable working of land . 115
" selecting seeds 115
True 72, 73
Umbelliferous 80
Wheat for 94
Seed-basket 121
" carrier 121
Seedling 156
Seedlings, the "damping off" of . . 405
Self-binder. See Binder . . . 177
Self-delivery machines . . . 176
Self-heal, seed of 81
Separator, advantages of the . . 492
Centrifugal 491
Belt-driven 492
Working the 491
"Shaking," shedding or, of grain . 168
Shallow-pan system of cream-raising 487
Sheaf-binding harvester. See Binder 177
" gauge 170
" ripening of grain in the . . 167
Sheaves, lifting broken stalks . . 185
" size of 185
" small 187
" for wheat 188
Shedding or shaking of grain . 168
Sheep, disposal of fat, in summer . . 63
" storing turnips for ewes . . . 362
" turnips consumed on the ground by . 357
" on turnips in winter 67

Sheep, turnip-tops as food for . . . 358
Sheep's fescue, seed of 86
Sheep's sorrel, seed of 78
Shelves of dairy 489
" milk 476
Shersrdia, seed of 81
Shirreff, Mr, on cross-fertilisation of grain 105
Shocking, stooking or, grain 185
Shovels, corn 227
Shrew, the 430
Sickle or "hook" 169
" form of 169
" smooth-edged 169
" still used 170
" thraving 170
" toothed 169
Sieve, milk- 488
Sieves, corn 226
Silica unnecessary for cereals . . . 7
Silos. See also Ensilage 289
Above or below ground? . . . 290
American and Canadian . . . 290
Concrete 290
With lever-pressure 290
Wooden 290
Singling and hoeing turnips . . . 352
Skim-milk cheese 510
Skimmer, cream- 489
Skylark, the 440
Sleepy cream 499
Slime fungi 417
"Slipcote" cheese 514
Slugs 472
Black striped or mottled . . . 473
That devour worms and insect larvæ . 474
Garden slug or small Arion . . 473
Grey field 473
Household or cellar 473
Large black 473
Preventive and remedial measures . 474
Sluices, troughs and 220
Smut in barley 416
" in oats 416
" in wheat 416
Snails 472
Allied banded 473
Garden 472
Hairy 473
Helix hortensis 472
Preventive and remedial measures . 474
Root- or bulb-eating 474
Small banded 473
Strawberry 472
Wood 472
Snow 69
Keeps land warm 69
In spring 59
Uses and drawbacks of . . . 69
Water and rain 69
Soda, nitrate of, excels ammonium-salts . 11
Soft cheeses 513
Soil for barley 133
For carrots 394
And climate for clovers . . . 241
And drainage-water experiments . 3
Effect of, on milling property of oats . 141
For flax 385
Grasses for different 245
For hops 377
Influence of electricity on . . . 404
" of season and, on oats . 139
For kohl-rabi 393
For mangel 363
Nitrogen of the, and of atmosphere . 6
Pastures on different 280
Soil—
At Rothamsted 2
For strawberries 400
And tillage for potatoes . . . 296
For turnips 328
For vetches 368
Wheat varying with 94
Sorghum 376
Sowers, broadcast 123
" drill 124
" hand broadcast 124
Sowing—
Advantages of drill- 159
Barley 131
Basket 122
Beans 148
Cabbages 371
Carrots 394
Cereals 115
Crimson clover 375
Deep and shallow 164
Different methods of, and germination 157
Disadvantages of broadcast . . 157
Flax 387
Grass seeds 247
Crops accompanying . . . 250
Hand-sowing 248
Harrow carriage 249
Harrows 248
Machine-sowing 248
Methods of sowing . . . 248
Rolling 249
Speed of the machine . . . 248
Time of sowing 247
Working wide harrows . . 249
Kohl-rabi 393
Machines 123
Oats 136
Peas 153, 154
Permanent pasture 286
Potato seed 313
Root, in summer 63
Rye 141
Sheet 122
With spring crops 250
Thick and thin 161
Turnips 334
Wheat in autumn 116
" in spring 119
Sparrow, the house- 439
" -hawk, the 431
Specific gravity of milk 480
" " of turnips . . . 327
"Speedwell" crystal churn . . . 497
Spicing, salting and, hay 277
Spiders 458
Spraying, the Strawsoniser at work . . 409
Spring 57
Advancing field-work 60
Advantages of work well advanced . 60
Birds in, storms 59
Cares of stock-owners in . . . 57
Cattle, disposing of fat . . . 59
Checking growth of turnips in . 359
Cottage gardening in 59
Crops, sowing with 250
Dunging for potatoes 302
Early rising and the joys of . . 57
Evaporation in 59
Evils of procrastination . . . 61
Farmer's duties in 58
" garden in 59
Field operations in 57
" -work in 58
Letting of grass parks in . . . 59

Spring—
Manured beans, sowing . . . 151
Neglected work insufficiently done . 60
Preliminaries 61
Rain in 59
Snow in 59
Sowing wheat in 10, 119
Subdivision of farm-work . . 60
Tillage for beans 150
" for turnips . . 329, 332, 333
Varieties of, wheat . . . 127
Vetches 368
Weather in 58
Winds in 58
Spring-tails or Collembola. . . . 466
Sprouting in the stook . . . 189
Squirrel, the 429
Stacks—
Cutting thatch 200
Drawn straw 196
Eave 195
English custom of thatching . . 199
Ensilage 290
Field 202
Finishing the 199
Form of 194
Forming the apex 197
Foundation for 193
Heating 200
Height of 195
Lifters. 273
Lozenge roping 198
Material for thatching . . . 196
Measuring heat in 201
Method of thatching 197
Net-mesh method of roping . . 199
Number of ropes. 198
Propping 200
Ropes 195
Roping 198
Round tops. 199
Second forker 194
Size of. 194
Straw for ropes 196
Straw-rope making 195
Thatching 196
Topping 195
Trimming 194
Tying ropes 198
Ventilators 201
Winding straw-ropes . . . 196
Stack-building, commencing . . . 193
" process of 193
Stacking beans 209
Cereals 189
" judging of dryness . . 189
" sprouting. 189
" time for drying . . . 189
" weather and drying . . 189
Hay 264
Peas 209
Poles for hops 383
Preparing for 189
Process of 189
Temporary, or "rickling" . . 189
Stackyard, arranging a . . . 193
Starling, the 436
"Starter" for butter-making . . 493
"Starters" or pure-cultures . . 504
Statistics, milk 480
Steading, corn at the 210
" work in the, in winter . . 66
Steam-power for cleaning clay land . 332
" for threshing-machines . . 216
Steeping flax 389
Sterilisation of milk 482
Sterilised milk bottles 482
Stilton cheese 510
Characteristics of 510
Climate and soil 511
Method of making 511
Stoats 425
Stock-dove, the 436
Steck-owners, cares of, in spring . . 57
Stocking of pastures 283
Stooking 186
" or shocking grain 185
Stooks, direction of 186
" size of 186
" of wheat 188
Storing—
Cabbages 373
Carrots 395
v. immediate selling of wheat . . 95
Kohl-rabi 393
Mangels 366
Parsnips 396
Potatoes 321
Turnips 356
Wheat, ancient practice in . . 95
Strainer, creamery 489
Straw. 102
Ancient uses of 104
Ash of. 102, 103
Barley 103
Bean- and pea- 148
Corn and, from high manuring . . 7
And hay elevator 215
Mixed with hay in drying . . 269
Oat and rye 103
Outlet for flax 391
For ropes 196
Rope making 195
Rope winding 196
Thatch-making machine . . . 197
Trusser 215
Wheat 102
Yield of 104
Strawberries 399
Black vine weevil 467
Duration of plants 399
Ground beetles 467
Irregular produce 399
Labour and soil 400
Planting 399
Price of 399
Snails 472
Strawsoniser, the 409
Stream, horse-power in a 218
Streamlet churn. 497
Stripper harvester 182
Stripping turnips 358
Stubble-rake 185
Subsidiary farm crops 392
Cabbages 393
Carrots 393
Flowers 401
Fruit 400
Hemp culture 402
Kohl-rabi 392
Lavender 402
Parsnips 396
Red-clover seed 401
Rhubarb 399
Vegetables 397
Woad 403
Sugar-beet 403
Summer 61
Atmospherical complications in . . 61
Beneficial influence of dew . . . 62

Summer—
Calendar and agricultural seasons . 62
Cattle, disposal of fat . . 63
Culture of barley . . 135
" of beans 152
" of oats 139
" of peas 154
" of wheat 128
Dairying in 63
The farmer's duties in . . . 64
" holiday 64
Forage crops, disposal of . . . 63
Grazing stock in 63
Haymaking in 63
Horses in 63
Hours of labour in 63
Insect attacks in 63
Light in 62
Rain 62
Repairing fences 63
Rest from field-work in . . . 64
Root sowing in 63
Sheep, disposal of fat 63
Summary of farm-work in . . . 62
Top-dressing of manures in . . 63
Weaning lambs in 63
The weather 61
Weed attacks in 63
Superphosphate for barley . . . 134
" for turnips 345
Swallow, the 437
Swartz system of raising cream . . 489
Swathe-turner 259
" turning and tedding . . . 259
Swede, seed of 73
Swedes 325
Swing churn 497

Tailing, topping and, turnips . . . 359
Tares, harvesting. See also Vetches . 209
Taylor's stack ventilator 202
Tedders injuring clover hay . . . 260
Tedding, experiments in 260
" forward and backward . . . 260
" with high wind 260
" swathe-turning and 259
Temperature of cream for churning . 494
" of the dairy 477
" of shallow pans 487
"Tennant" grubber 330
Testing percentage of cream in milk . 479
Thatch, cutting 200
" potato-shaws as 323
Thatch-making machine 197
Thatching peas and beans 209
" method of 197
" process of. See also Stack . . 195
" turnip-store 361
Thermometers, dairy 477
Thinning carrots 395
" and hoeing kohl-rabi . . . 393
" -machines 353
" of turnips 327
Thistle, seed of field- 79
Thousand-headed kale 374
Thraving 170
Threshing grain in winter 67
" and winnowing corn 222
Threshing-machine, an ancient . . . 210
Care in feeding 223
Hand 216
Hands required for 213
Horse-power for 221
Irregular driving 223
Motive power for 216

Threshing-machine—
Portable 213
Preparing for 223
Removing straw 223
Safety drums 215
Saving of labour 212
Scotch 211
Straw and hay elevator . . . 215
Straw-trusser attached to . . . 215
Water-power for 217
Throstle, the 436
Throw-crooks 195, 196
Thrush, the 436
Thunderstorms and haymaking . . . 263
Tillage for barley 131
For carrots 394
For flax 385
For hay 251
For kohl-rabi 393
For mangels 363
For peas 153
Soil and, for potatoes 296
Spring, for beans 150
For turnips 328
Tillering 161, 165
" multiple stems or 157
Timothy hay, cutting 263
" grass, seed of 84, 239
Tip-cart, farm 349
Titmice 437
Tobacco 403
Tomato root-rot 471
Topping and tailing turnips . . . 359
Tractors, motor 182
Transplanting seed 166
Trees, winter washing of fruit- . . . 457
Trefoil, seed of 76
Trimming stacks 194
Troughs and sluices 220
Trusser, straw- 215
Tubular milk-cooler 483
Tufted hair-grass, seed of 89
Tulip-root of oat, or segging . . . 471
Turbine, the 221
" -driven pasteuriser 481
Turnips 324
Advantages of the crop . . . 324
" of raised drills . . . 334
After cultivation 356
Analysis of 394
Application of manure for . . . 348
Artificial manure alone . . 348, 351
Atmospheric nitrogen for . . . 342
Autumn cleaning 331
" dunging and ploughing . . 332
" and winter ploughing . . 329
Basic slag for 346
" *v.* superphosphate . . 350
Broadcast sowing of 335
Care in thinning 327
Care in use of mineral phosphates . 345
Cart for dung on steep land . . 349
Carting 360
" dung into drills . . . 348
Cheapest phosphate for turnips . . 344
Checking growth in spring . . . 359
Clay soils unsuitable for . . . 328
On very strong clays 333
Climate and soil to be considered . 345
Climatic influences on 326
Common 325
Consolidating the drill-top . . . 337
Consumed on the ground by sheep . 357
Crop 324
Cross-cultivation 332

Turnips—
Dependence on manure . . . 339
Depth of the drill 335
" of seed 339
Diamond-back moth 464
Disadvantage of raised drills . . 334
Distance between plants . . . 354
Distribution of the plants . . . 327
Drill-plough 334
" -sower 337
" for sowing on the flat . . 338
Drilling on the flat 335
" manure and seed . . . 337
Dung 348
" spreading apparatus . . . 349
Is dung essential in turnip culture? . 346
Dunging and sowing in drills . . 336
Earthing-up 356, 362
Elements absorbed by roots . . 340
" in manure for . . . 340
English practice of manuring . . 342
Exceptional conditions in preparing land 331
Excess of potash injurious . . . 343
An exhausting crop 339
Experiments at Carbeth . . . 342
" in north of England . 350
" in south of England . 350
" in north of Scotland . 350
" at Pumpherston . . 37-40
Farmyard mauure for 346
Fine grinding in manure . . . 350
Finger-and-toe, or club-root . 49, 417
The force employed 336
Forking out weeds 333
Gall-weevil 463
Growing may be overdone . . . 324
" roots in squares . . . 355
Grubbing or cultivating in spring . 332
Half-ploughing 332
Hand-hoes 353
Harrowing turnip-land . . . 330
Heavy dressings 347
Hoeing—
Advantages of drills . . 355
After cultivation 356
Care in 356
Distance between plants . . 354
Drill-harrowing or horse-hoeing . 352
" scarifier 352
Good and bad hoeing . . . 353
Growing roots in squares . . 355
Hand-hoeing in flat rows . . 353
Harrowing across flat rows . 352
Hoeing-matches 353
Influence of weather . . . 352
Medium and large roots . . 355
Moderate intervals between plants 355
Process on drills 353
Speed of hoers 353
Thinning by hand . . . 354
Transplanting plants . . . 354
Ill-shaped 326
Insect attacks on 326
Introduction of 324
" of drill-sowing . . 334
Irregularity in growth of . . . 355
Keeping properties of 357
Lifters 360
" ahead of carters . . . 360
" hints to 360
Lifting appliances 358
Manure injuring seeds . . . 338
Chief manure for 341
Manures preventing blanks . . 351

Turnips—
Manures for turnips and beans . . 33
Manuring 339
Mildew of 411
Mineral phosphates 345
Mode of pulling 359
Moderate dressings of dung . . 347
Moth 465
Mud-beetle 462
New varieties 325
Nitrogen for 341, 342
" potash, and phosphoric acid for 341
" in the soil 342
Normal conditions in preparing land . 329
Number per acre 327
Opening and closing drills . . . 337
Order of using 326
Overworking land injurious . . 333
Pests 356
Phoma fungus 414
Phosphates for 343
" too much reliance on . 344
" with dung . . . 344
" without dung . . . 344
Pits in the field 361
Ploughing or grubbing . . . 330
Potash for 343
Preparing clean land 333
" foul clay land . . . 331
Prevailing intervals between . . 354
" systems of growing . . 329
Produce of different varieties . . 325
Proportion of leaf and root . . 326
Pulverising ploughs 330
Pumpherston, manuring at . . 37, 40
Quantities of manures for . . . 347
Quantity of roots to be left for sheep . 357
" of seed required . 338
In raised drills 334
Raised drills on strong clays . 335
Recouping the soil . . . 344
Removing weeds 330
Results from short intervals between plants 354
Rothamsted trials 342
Sawfly 466
Scottish dressings of manure . . 347
Seed of 73
Seed-drill 337
Selection of seed 338
Sheep on 67
Simultaneous drilling and sowing . 336
Singling and hoeing 352
Soil, climate, and system of tillage 329
Soils for 328
Southern customs of sowing manure 349
" dressings 348
Sowing 334
" artificial manure . . . 349
Specific gravity of 327
Spring tillage 329
" " of light clean land . 333
" " of strong land . . 332
Stale seed-bed undesirable . . 336
Steam-power for cleaning clay land 332
Storing 356
Advantages of 357
Dry weather best for . . . 360
For ewes 362
In furrows 361
In houses objectionable . 362
In hurdle enclosures . . 362
Importance of storing roots . 360
Keeping properties . . . 357
Methods of 361

Turnips—
Storing—
Time for storing swedes . . 357
When to store white 357
Stripping 358
Subordinate elements in manure . 340
Superphosphate manuring exhausts soil 344
Superphosphates 345
Supplementing dung 346
Swedes 325
For table use 398
Taking roots from the store . . 361
Temporary storing on lea . . . 361
Tennant grubber 330
Test the soil 343
Thatching store 361
Thick and thin sowing . . . 338
Tillage of land for 328
Time of sowing 338
Top-dressing 350
Topping and tailing 359
Tops 398
" as food for stock . . . 358
" as manure 358
Trimming knife 359
Uncertainties in manuring . . . 340
Varieties of 325
Water drill 337
" and dry drills compared . . 338
Weeds, second crop of . . . 331
" do not break . . . 332
Welsh trials in manuring . . . 351
White rot of 418
Width of drills 334
" of rows 335
Yield and quantity of dung . . 347

Umbelliferous "seeds" 80
Undershot water-wheels 217
Uredineæ 414
Useful flies 469
" Hymenopters 469
" insects 469
Ustilagneæ, the 416

Vat, milk- 502
Ventilation in churning 499
Ventilators, stack 201
Verandah of dairy 476
Vetches 368
And cleaning land 369
Cutting 369
Harvesting 209
For horses 368
Land for 368
Manuring 369
Seed 369
Spring 368
Utilising 368
Winter 368
Vilmorin's classification of wheat . . 93
Voles 428
" measures against 429

Waggon, farm 191
Wagtails, water- 437
Wallace's hay-sledge 266
Water-ballast rollers 143
" -channels in ploughed land . . 66
" -courses, finishing processes . . 118
" drill for turnips 337
" -furrows, formation of . . . 137
" " under drainage *v.* . . 127
" " inland 126
" meadows, time for irrigating . . 66
Water power for threshing-machines 216
" -rat or vole 428
" -shrew 431
" -supply, measuring the . . . 217
" " to pastures 284
Water-wagtails 437
Water-wheel 217
" speed of bucket 221
Way-bread, seed of 77
Weaning lambs in summer . . . 63
Weasel, the 425
Weather—
Autumn, and field operations . . 65
Effects of, and manures on barley . 22
And field operations in winter . 66
Germination of barley and the . 132
And harvest 65
And haymaking 253
Haymaking controlled by the . 258
In spring 58
In summer 61
In winter 68
And work 57
Wechts, barn, or baskets . . . 225, 226
Weed-hook 129
Weeding cereal crops 129
" flax 388
Weeds, attacking, in summer . . . 63
" in pastures 284
" on turnip land 330, 333
Weevils—
Bean 459
Black vine 467
Cabbage root gall 448
Corn and rice 455
Pea and bean 459
Raspberry 467
Turnip and cabbage gall- . . . 463
Weighing-machines 230
Weight of barley 97
" and specific gravity of milk . . 480
" of oats 99
" of rye 101
" of wheat 94
Wensleydale cheese 513
Wheat—
Advantages of the double-furrow plough 120
Advantages of grubbing . . . 117
After beans 119
After grass 119, 127
After potatoes 119
Ancient practice in storing . . . 95
Antiquity of, cultivation . . . 95
Art of sowing 122
Autumn 128
Autumn and winter weather for . 13
Black rust of 414
Braird, harrowing the . . . 250
Breeding on Mendel's principles . 110
Broadcast-sowers 123
Bulb fly 451
Bunt of 416
Classification by the ear . . . 91
Classifying by the grains . . 92
Colour of 91
Crop values 90
Cropping rank 129
Date of spring sowing . . . 119
Double-furrow plough . . . 120
Drill-sowers 124
Ear-cockle 470
Experiments at Rothamsted . . 3
" at Woburn . . . 43
Fallow 117

Wheat—
For flour 93
Flowering season 130
Frost throwing out plants . . . 118
Grubbing for 117
Haud broadcast sowers . . . 124
Harrowing 118, 125
Hoeing drilled 129
Judging 93
Kernel and husk of 95
Land for spring 119
Late varieties of 128
Limits of, culture 95
Manuring of. See also Rothamsted 3, 128
Midge 452
Number of grains in a bushel . . 94
One-hand sowing 121
Origin of 95
Over-luxuriance in autumn . . 128
Pickling 130
Placing sacks in the field . . . 120
Plant in the state of germination . 157
Ploughing for 117
Preserving, in granaries . . . 94
Roots of sown 165
Quantity of ash in an acre of . . 95
Quantity of seed for 118
Reaping 188
" machines 188
Relation of ear and grain . . . 93
Riddle 225
Rolling 118
Rust in, description of figures . . 419
Scythe unsuitable for reaping . . 188
For seed 94
Seed-basket 121
" carrier 121
" sacks 121
Self-binders for reaping . . . 188
Sheaves for 188
Simple classification 91
Smut 416
Sowing in autumn 117
" in spring 119
" machines 123
Spring seed from early districts . . 128
Stack-heating 200
Stooks 188
Storing *v.* immediate selling of . . 95
Straw 102
" ash of 102
Summer culture of 128
Tillage for spring 120
Time to cut 188
Time for sowing in autumn . . 118
Top-dressing 130
Turning pickled 131
Two-hand sowing 122
Under-drainage *v.* water-furrows . 127
Varieties of spring 127
Variety to sow 118
Varying with soil 94
Vilmorin's classification of . . . 93
Water-courses 118
" furrows 126
Weight of 94
Where to begin sowing . . . 121
Width of drill 124
Wheat, yellow rust of 415
Whin 376
White clover 243
" campion seed of . . . 74
" variety of 376
Winds in spring 58
Winnowers, modern 224
Winnowing, threshing and, corn . . 222
Winter 66
Attention to ewes in 67
Autumn and ploughing for turnips . 329
" weather for wheat . . 13
Beneficial influence of frost . . 68
Best season for draining . . 66
Carting manure in 67
Cold and frost 68
Domestic enjoyment 68
Feeding stock in 67
Field work in 66
Hoar-frost 69
Hospitality 67
Implements used in 67
Injury by hoar-frost 69
Irrigation in 66
Marketing grain 67
Planting hedges 66
Plants uprooted by frost . . . 68
Ploughing lea in 66
Rain 68
Recreation 67
Sheep on turnips 67
Snow 69
" keeps land warm . . . 69
" -water and rain . . . 69
Threshing grain in 67
Uses and drawbacks of snow . . 69
Vetches 368
Water channels in ploughed land . 66
Weather in 68
Weather and field operations in . . 66
Work in the steading 66
Wireworms 453
" false 470
Woad farming 403
Woburn experiments with manures, &c. . 42
Wood-mouse 427
" snail 472
Wooden riddles 225
" silos 290
Wood-pigeon, the 434
Wood's new century reaper and binder . 180

Yarrow, seed of 79
Yellowhammer, the 438
Yield—
Of butter 478
Of meal 100
Of rye-straw 104
And weight of barley 97
And weight of oats 99
And weight of rye 101
Yorkshire cheese 513
" fog, seed of 83
" trials in manuring barley . . . 135

Zinc dishes unsuitable for milk . . . 488
Zoology, mammals in relation to Agriculture 424

PRINTED BY WILLIAM BLACKWOOD AND SONS.